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Environmentally Friendly Food Choices: Factors That Influence Consumers' Selection of Meals, Eco-Labels, and Alternative Proteins

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Contents

Summary

Food systems must be transformed to restore planetary health and ensure a continued food supply. Consumers are central to this transformation, as they can improve their eating habits and simultaneously drive demand for sustainable food production. Some ways in which consumers can make a positive impact are by choosing plant-based over animal-based meals, replacing animal-based protein with alternative proteins, and opting for eco-labeled over conventional products. However, certain gaps exist in our understanding of these environmentally friendly food choice behaviors. To address these gaps, the current dissertation investigates factors that impact consumers' selection of environmentally friendly meals, eco-labels, and alternative proteins.

Since meals are fundamental to a persons' daily eating routines, the way we compose them greatly impacts our environmental footprint. To elaborate on how we can shift toward more environmentally friendly meal composition habits, Chapter 2 investigates how and why Swiss consumers chose foods when they are prompted to compose an environmentally friendly meal at a fake food buffet. It reveals that consumers trying to compose an environmentally friendly meal (1) included too many animal-based foods (especially egg and dairy); (2) didn't include enough vegetables (especially legumes) and novel alternative proteins (e.g., vegetarian burger patties); and (3) relied too heavily on a foods' regionality, seasonality, and organic production as indicators of food sustainability. Evidently, misconceptions about food sustainability and a strong unwillingness to shift from animal- to plant-based eating patterns exist.

As many products available in supermarkets today contain unsustainable ingredients (e.g., palm oil), our use of eco-labels can greatly affect our environmental footprint. Chapter 3 explores this using palm oil and the Roundtable of Sustainable Palm Oil (RSPO) label as a case study. It reveals that although Swiss consumers have a negative perception of palm oil, there is a low awareness of which products contain palm oil and a low familiarity with the RSPO label. Consequently, it is unlikely that consumers can make more sustainable palm oil-based purchases, even if they want to. Eco-labels can therefore only be effective as long as certain pre-requisites are met on the side of the consumers.

To reduce the large environmental burden of animal-based food production, consumers can opt to increase their reliance on various alternative proteins. Chapter 4 investigates consumers' perceptions of one of the most globally controversial alternative proteins: insects. Specifically, it presents a meta-analysis that synthesizes previous studies on entomophagy acceptance and reveals that affect-based factors (e.g., neophobia and disgust) are unanimously the largest

barriers to the willingness to consume (WTC) insects. In contrast, consumer education, familiarity, and curiosity can increase the WTC insects. The analysis suggests that entomophagy is unlikely to be globally accepted any time soon; focusing on winning over "first adopters" (e.g., food neophiles) as compared to the broad public is perhaps the best strategy for promoting entomophagy.

Since a variety of novel alternative protein technologies have been developed in recent years, it is vital to understand how to promote the public's adoption thereof. Since Asia is a promising market for such products, Chapter 5 investigates which attributes of a novel microalgae (MA)-based food product increase the acceptance in a Singaporean sample. It appears that an MA-based product that is framed as a meat or fish substitute; aligns with traditional Asian cuisine; is framed as environmentally friendly, innovative, and trendy; and has emphasized health benefits may be well received by Singaporean consumers. The findings imply that consumers' perceptions of alternative proteins are not a one-size-fits-all; Therefore, novel alternative protein products must be tailored toward the specific (cultural) market to which they are being released.

Overall, the current dissertation points to ways in which consumers, the food industry, policymakers, schools, the media, and researchers can contribute to more environmentally friendly food consumption patterns. Individuals, for instance, can increasingly opt for plant- over animal-based foods, consider the sustainability of the ingredients in their purchased products, and adopt alternative proteins into their diets. To support this, it will be necessary to improve the sensory appeal of plant-based diets, and the effectivity of tools to signal sustainability (e.g., eco-labels). Consumers' sensory preferences, food neophobia, and disgust will always be barriers to the acceptance of novel foods. However, as consumers gain more education about and exposure to these new foods, acceptance will grow slowly but surely. For the near future, the perhaps best strategy is to target specific consumer segments (e.g., food sensation seekers for insects, and the Asian market for MA) to secure "first adopters." Research must increasingly consider the perspectives of consumers of all backgrounds (varying in terms of e.g., culture, income, or age) to improve dietary sustainability on a global scale.

Zusammenfassung

Ernährungssysteme müssen transformiert werden, um die Gesundheit des Planeten und eine kontinuierliche Nahrungsmittelversorgung zu gewährleisten. Konsumenten nehmen hierbei eine zentrale Rolle ein, da sie ihre Ernährung verbessern und gleichzeitig die Nachfrage nach nachhaltiger Lebensmittelproduktion vorantreiben können. Konsumenten können einen positiven Einfluss ausüben, indem sie zum Beispiel pflanzen- statt tierbasierte Mahlzeiten zu sich nehmen, tierische Proteine durch alternative Proteine ersetzen, und Produkte mit Umweltzeichen ("Eco-labels") gegenüber konventionellen Produkten bevorzugen. Allerdings gibt es gewisse Lücken in unserem Verständnis dieser umweltfreundlichen Verhaltensweisen. Um diese Lücken zu schließen, untersucht die vorliegende Dissertation eine Reihe von Faktoren, die die Entscheidungsfindung für umweltfreundliche Mahlzeiten, Eco-labels, und alternativen Proteinen beeinflussen.

Mahlzeiten sind für die tägliche Essroutine eines Menschen von grundlegender Bedeutung. Die Art und Weise, wie wir Mahlzeiten also zusammenstellen, wirkt sich stark auf unseren ökologischen Fußabdruck aus. Um zu erörtern, wie wir hierbei zu umweltfreundlicheren Gewohnheiten übergehen können, untersucht Kapitel 2, wie und warum Schweizer Konsumenten Lebensmittel auswählen, wenn sie aufgefordert werden, eine umweltfreundliche Mahlzeit an einem "Fake Food Buffet" zusammenzustellen. Wenngleich die Probanden versuchten, eine umweltfreundliche Mahlzeit zusammenzustellen, (1) wählten sie zu viele tierische Lebensmittel (insbesondere Eier und Milchprodukte) aus; (2) wählten sie nicht genügend Gemüse (insbesondere Hülsenfrüchte) und neuartige alternative Proteine (z. B. vegetarische Burger-Patties) aus; und (3) liessen sie sich zu stark von der Regionalität, Saisonalität und der biologischen Produktion von Lebensmitteln als Nachhaltigkeitsindikatoren leiten. Offensichtlich gibt es Missverständnisse über die Nachhaltigkeit von Lebensmitteln und eine Abneigung, von tierische auf pflanzliche Ernährungsmuster umzusteigen.

Da viele Produkte in unseren Supermärkten umweltproblematische Inhaltsstoffe (z. B. Palmöl) enthalten, wirkt sich sowohl der Kenntnisstand wie auch die Akzeptanz von Eco-labels auf unseren ökologischen Fußabdruck aus. Kapitel 3 untersucht dies anhand von Palmöl-Produkten und dem Roundtable of Sustainable Palm Oil (RSPO) Label als Fallstudie. Schweizer Konsumenten nehmen Palmöl zwar grundsätzlich als negativ wahr, haben aber ein geringes Bewusstsein dafür, welche Produkte Palmöl enthalten, und eine geringe Vertrautheit mit dem RSPO-Label. Folglich ist es unwahrscheinlich, dass Konsumenten ihre Einkäufe

hinsichtlich einer Verringerung von umweltschädlichem Palmöl verändern werden. Eco-labels können daher nur wirksam sein, wenn auf Seiten der Konsumenten bestimmte Voraussetzungen erfüllt sind.

Um die Umweltbelastung tierischer Lebensmittelproduktion zu verringern, könnte man parallel den Konsum von alternativen Proteinen erhöhen. Kapitel 4 untersucht die Konsumentenwahrnehmung eines der weltweit umstrittensten alternativen Proteine: Insekten. In dieser Metaanalyse werden frühere Studien zur Entomophagie-Akzeptanz systematisch zusammengestellt und analysiert. Affektbasierte Faktoren (z. B. Neophobie und Ekel) ergaben sich als die größten Hindernisse für die Konsumbereitschaft von Insekten. Im Gegensatz dazu können Konsumentenaufklärung, -vertrautheit und -neugier die Konsumbereitschaft von Insekten potenziell erhöhen. Es ist jedoch unwahrscheinlich, dass sich Entomophagie in absehbarer Zeit in größerem Massstab etablieren wird. Es wäre also ratsam, die Entomophagie-Akzeptanz gezielt in bestimmten Konsumentensegmenten zu fördern, und nicht auf die Gesamtheit der Konsumenten abzuzielen.

In den vergangenen Jahren wurde eine Vielzahl neuartiger alternativer Proteintechnologien entwickelt, deren gesellschaftliche Akzeptanz bisher jedoch noch nicht in umfassender Form untersucht wurde. Da Asien ein vielversprechender Markt für solche Produkte ist, untersucht Kapitel 5 in einer Fallstudie für Singapur, welche Eigenschaften ein neuartiges Lebensmittel auf Mikroalgenbasis idealerweise besitzen sollte. Basierend auf der vorliegenden Konsumenten-Stichprobe, sollte ein solches Produkt (1) als ein Fleisch- oder Fischersatzprodukt vermarktet werden; (2) zur traditionellen asiatischen Küche passen; (3) als umweltfreundlich und innovativ wahrgenommen werden; und (4) gesundheitliche Vorteile besitzen. Die Ergebnisse implizieren, dass neue nachhaltige Produkte auf die spezifischen (kulturellen) Bedürfnisse eines Marktes zugeschnitten werden sollten.

Insgesamt zeigt die vorliegende Dissertation, inwieweit Konsumenten, Lebensmittelindustrie, Politik, Schulen, Medien und Forschung zu einem umweltfreundlicheren Ernährungsverhalten beitragen können. Einzelpersonen können sich zunehmend für pflanzliche, statt tierische Lebensmittel entscheiden, die Nachhaltigkeit der Inhaltsstoffe ihrer gekauften Produkte berücksichtigen und alternative Proteine in ihre Ernährung aufnehmen. Um dies zu unterstützen, muss die geschmackliche Attraktivität pflanzlicher Ernährungsmuster und die Wirksamkeit von Nachhaltigkeitssignalen (z. B. Eco-labels) verbessert werden. Sensorischen Vorlieben, Neophobie und Ekel der Konsumenten werden immer ein Hindernis für die Akzeptanz von neuartigen Lebensmitteln darstellen. Allerdings können Konsumentenaufklärung und -erfahrung diesem Problem potenziell

entgegenwirken, wobei man sich wohl auf eine längere Zeitskala einstellen muss. Ausserdem sollte die Forschung zunehmend die Diversifizierung von Konsumenten mit unterschiedlichem Hintergrund (z. B. in Bezug auf Kultur, Einkommen oder Alter) berücksichtigen, um Verhaltensmuster und ihre Nachhaltigkeit auf globaler Ebene zu fördern.

Abbreviations

ANOVA	Analysis of Variance
BMI	Body Mass Index
CA	Correspondence analysis
CHF	Swiss Franks
EP	Eco-points
ESPO	European Sustainable Palm Oil
ETH	Eidgenössische Technische Hochschule
FAO	Food and Agriculture Organization of the United Nations
FFB	Fake food buffet
FFQ	Food frequency questionnaire
GHG	Greenhouse gas
LCA	Life Cycle Assessment
MA	Microalgae
OECD	The Organization for Economic Co-operation and Development
PCA	Principal Component Analysis
PBMA	Plant-based meat alternative
PHD	Planetary Health Diet
RSPO	Roundtable of Sustainable Palm Oil
SPSS	Statistical Package for the Social Sciences
VR	Virtual reality
WTB	Willingness to buy
WTC	Willingness to consume

Chapter 1

General Introduction

1.1. Consequences and challenges of the current global food system

History has seen numerous civilizations die out because they degraded their environment and exhausted their resources. The Maya, for instance, stripped large areas of their landscape bare to feed their growing society (Peterson & Haug, 2005). As a result, their deforested and over-farmed lands were left infertile and prone to drought, causing widespread famine and water shortages. Even though many factors likely contributed the Maya demise, it is believed that their negligence toward their own homelands played an important role (Peterson & Haug, 2005).

The past may repeat itself if the current practices of food production, processing, and dissemination aren't dramatically improved. Among being a major driver of climate change (Vermeulen et al., 2012), the global food system greatly contributes to increased land-use change and biodiversity loss (Foley et al., 2005; Newbold et al., 2015), the depletion of freshwater resources (Wada et al., 2010), and the eutrophication of aquatic and terrestrial ecosystems (Cordell & White, 2014; Diaz & Rosenberg, 2008). In quantitative terms, a quarter of global greenhouse gas (GHG) emissions, half of the world's habitable land use, and 70% of global freshwater withdrawals can be traced to agriculture (Poore & Nemecek, 2018).

In addition to these environmental challenges, it is becoming increasingly difficult to feed the rapidly growing world population. By 2050, global caloric demands will double (Krausmann et al., 2013). Socioeconomic factors can aggravate this situation, as poverty-driven urbanization, economic instability, and food contamination limit consumers' access to sufficient, nutritious, and safe food. As natural resources, such as freshwater and arable land, will gradually be exhausted, it is questionable how food production can be intensified to meet humanity's increasing needs.

To reduce environmental damage and accommodate growing nutritional demands, a shift away from our reliance on animal-based food production is vitally necessary (Poore & Nemecek, 2018; Willett et al., 2019). Within the food sector, the production of meat, fish, dairy, and eggs has by far the most significant impact on the environment, as exemplified by their high GHG emissions (see Figure 1). At the same time, animal husbandry is extremely resource intensive (e.g., in terms of land use, as seen in Figure 1), making it unsuitable to be the main protein source for a world in which freshwater and arable land are quickly depleting. Our dependence on livestock farming, which contributes up to 50% of the global agricultural gross domestic product (Herrero et al., 2016), is especially problematic, as it diminishes natural resources and deteriorates air quality, the global climate, soil quality, biodiversity, and water

quality (Leip et al., 2015; Tullo et al., 2019). While the production of animal-based foods can contribute to humans' nutritional needs and food security in harsh and low-mechanized environments, the current production and consumption levels of these foods are unnecessarily high.

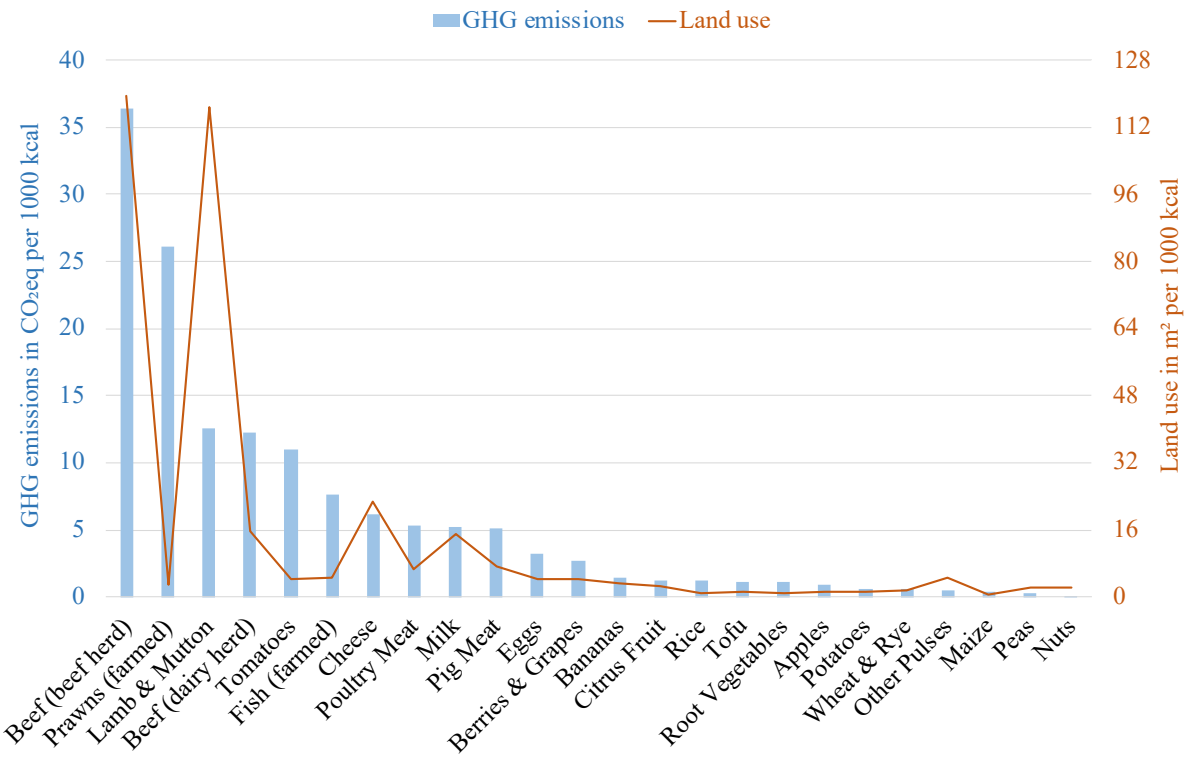

Figure 1. Estimated global GHG emissions (in carbon dioxide-equivalents (CO_2eq)) and land use (in meters squared (m^2)) to produce 1000 kilocalories of a given food product based on Poore & Nemecek (2018).

Apart from the large impact of animal husbandry on the world's climate and resources, the production of many other widely consumed foods deteriorates the environment. First, the cultivation of coffee, cacao, tea, and vegetable oil, for example, causes a large degree of deforestation, pollution, soil erosion, land degradation, and biodiversity loss in their production countries (Sunde et al., 2011). As these consequences are not necessarily expressed in terms of GHG emissions or land use, the negative impact of these foods is not illustrated in Figure 1. Second, the cumulated environmental impact of foods such as maize, wheat, or rice (see Figure 1) is also not to be underestimated, as these grains largely contribute to feeding both humans and livestock (Reynolds et al., 2015). Third, transport (distance, mode of transport, and type of transport), production method (organic vs. conventional), and seasonality can in some cases

also significantly affect a food's environmental footprint. As can be seen in Figure 1, for instance, Poore and Nemecek (2018) yielded high GHG emissions for tomatoes, yet significantly lower emissions for all other vegetables—a difference that could have been caused by particularities in these foods' transport, seasonality, and production method. However, since the impact of these variables on a food's environmental footprint varies greatly depending on the calculation method and context, overall, they are not deemed the most reliable indicators of a food's sustainability (Macdiarmid, 2014; Nemecek et al., 2016).

To illustrate a diet that could healthily sustain both the environment and the world population for many years to come, the EAT–Lancet Commission proposed a reference diet called the Planetary Health Diet (PHD) as pictured in Figure 2 (Willett et al., 2019). The PHD is predominantly plant-based and includes only modest amounts of meat, fish, and dairy. Furthermore, it promotes a high variety of vegetables and fruits, favors saturated over unsaturated fats, limits energy-dense and nutrient-poor foods (e.g., refined grains, fats, and sweets), and recommends an average intake of 2500 kcal per day.

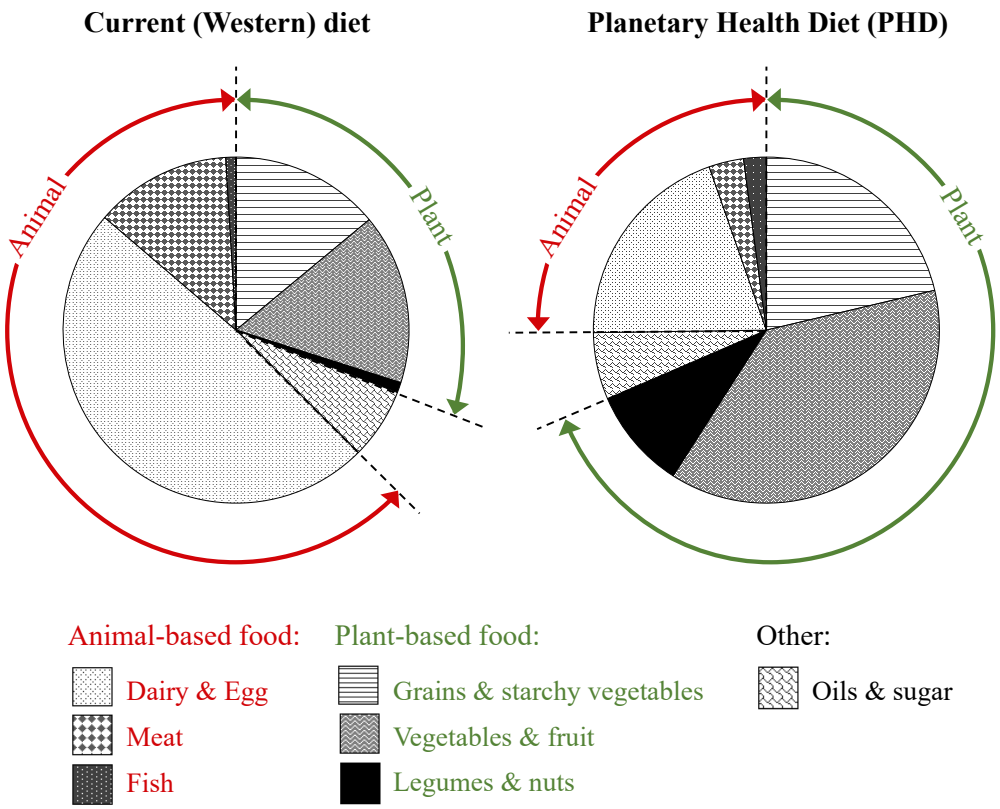

Figure 2. The current (Western) diet vs. the PHD. The Western diet is based on an example of a Western country, Germany (Wiegmann & Scheffler, 2023). Oils and sugar are in the "other" category, as they are supplements that can be added to both animal- and plant-based food, but do not form the principal constituent of any given meal.

For current Western consumption patterns to align closer to the PHD (see Figure 2), several changes are necessary: (1) Overall, decreasing the global nutrient reliance on animal-based foods and, in turn, increasing the reliance on plant-based foods is most important for improving dietary environmental friendliness; (2) To ensure that people consume enough calories and proteins on a plant-based diet, an increased global uptake of non-animal proteins (i.e., alternative proteins), such as legumes, insects, or novel cell technology, is desirable; (3) A shift away from the production and intake of energy-dense and nutrient-poor foods (commonly referred to as "processed foods") would be beneficial, as these products contain unhealthy and unsustainable ingredients; (4) And lastly, overconsumption is to be avoided, as this is one form of wasting food.

1.2. Increasing consumers' environmentally friendly food choices

To alleviate environmental damage and overcome the challenges of the current global food system, a drastic transformation of food production and consumption habits is needed. Improving the food industry will be difficult, as political, economic, and social factors are involved. Despite some innovative actors and early adopters, the food industry as a whole can be expected to be reluctant to abandon well-established and profitable business models. Thus, changes to the food system will have to be initiated by individual consumers, who can improve their food choices and simultaneously nudge actors in the food system (e.g., industry and policy makers) through demand.

Considering the guidelines provided by the PHD, the current dissertation will focus on the following food choice behaviors that may contribute to improving consumers' environmental footprints.

1.2.1. Composing plant-based meals instead of animal-based meals

Meals can be seen as the functional unit of our daily diet (Mäkelä, 2009): Most of the foods we eat throughout the day come from our breakfast, lunch, and dinner meals. Since meals contribute significantly to our daily nutritional needs, the fundamental ways in which we compose them can have a significant effect on our dietary environmental footprint. Consider, for example, the typical meal "format" that consumers tend to adhere to: In the Western world, meals are habitually composed based on a tripartite structure of meat/fish, vegetables, and starchy staples (e.g., noodles, bread, rice) (Douglas & Nicod, 1974; Van't Riet et al., 2011). Consumers view animal proteins as the most favorable and important part of the dish, which

they cannot do without (Schösler et al., 2012). Changing consumers' perceptions and behavior around this pattern (e.g., encouraging consumers that meals can be "complete," even without the meat/fish component) can be one way to facilitate environmentally friendly meal composition.

1.2.2. Replacing animal-based protein with alternative protein

Since a reduction in animal-derived foods is key to improving dietary sustainability, a higher global nutrient reliance on alternative proteins (i.e., non-animal protein) is necessary (see Figure 3).

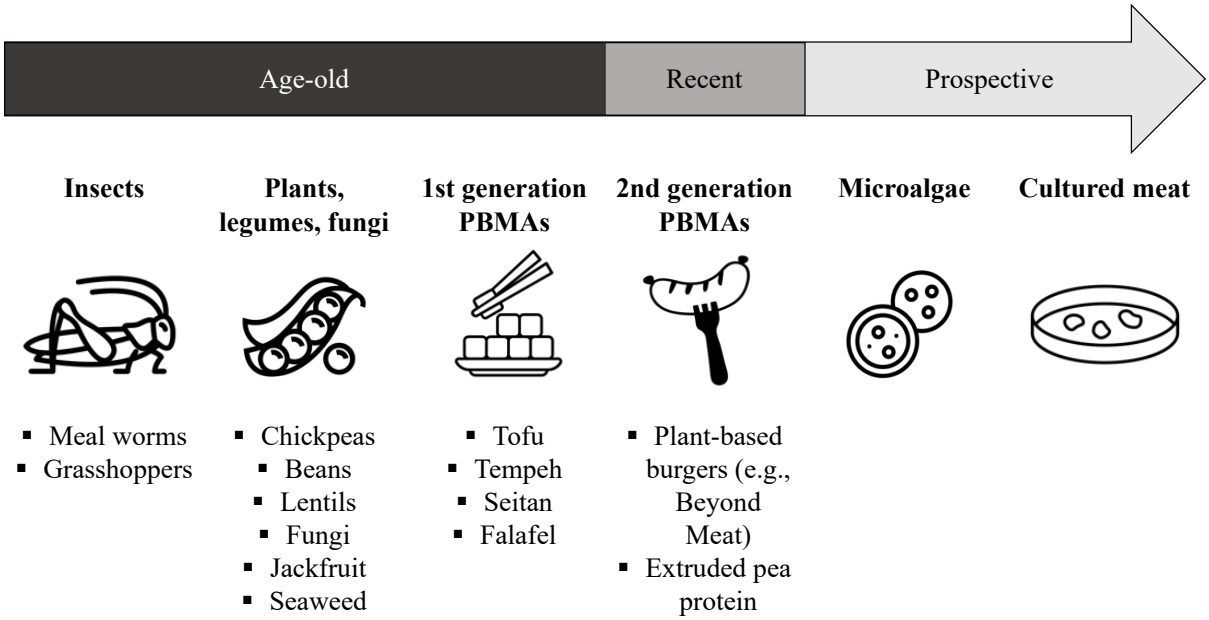

Figure 3. Overview of alternative proteins (i.e., non-animal proteins) based on Jahn et al. (2021). PBMAs = Plant-based meat alternatives.

Alternative proteins, such as those derived from insects, plants, legumes, fungi, and seaweed, have been part of the human diet for thousands of years. Using different processing methods that have allowed some of these foods to be transformed into meat-like textured products (e.g., fermenting), humans have created the first generation of plant-based meat alternatives (PBMAs), such as tofu, tempeh, seitan, and falafel. While legumes, seaweed, and first generation PBMAs are, to this day, dietary staples in Asian, South American, and Middle Eastern countries, they are underused in Western diets (Henn et al., 2022). Even more pronounced is the role of insects because their consumption is highly uncommon in most of

the Western world (Van Huis et al., 2013). Considering that the production and preparation of these foods have already been optimized throughout many generations and cultures, promoting an increased uptake of these proteins in Western countries could be a cost-efficient avenue for improving global dietary sustainability.

In recent years, modern food processing (e.g., extrusion) has allowed the creation of a second generation of PBMA, such as plant-based sausages, plant-based burgers, or products by the brands Beyond Meat, Quorn, and Planted. In contrast to traditional foods, such as tofu and falafel (which originate from non-Western countries), these novel "ready-to-eat" products tend to be created by European and North American companies and are meant to mimic meat in terms of taste, smell, texture, and appearance. As the overall demand for these foods is still low (Michel et al., 2021), it is desirable if more consumers consider these products in place of conventional meat.

To ensure a sustainable future food supply, novel protein sources need to be added to existing animal-, insect-, and plant-based foods. In this regard, cell-based technologies, such as MA (i.e., single-celled algae) and cultured meat (i.e., cultivated animal cells in vitro), have great potential because they can be nutritious, have low environmental footprints, and have low resource requirements (Smetana et al., 2015; Smetana et al., 2017). However, these technologies are currently still energy intensive, mainly due to the small scale of current production facilities (Smetana et al., 2015). Furthermore, it is unclear to what extent these novel products will be accepted by consumers. Consumers' increased adoption of these novel foods is vital, as it promotes the scale-up of these novel technologies, which will in turn lead to more cost-effective production.

1.2.3. Choosing eco-labeled products over conventional products

Due to the commonly applied focus on animal protein and their large impact on the overall environmental footprint of a diet, many other high-impact foods, such as vegetable oils, coffee, and cacao, are easily overlooked in this regard. However, especially the impact of "hidden" fats in many processed foods can easily add up within someone's diet, as these ingredients are contained in a large variety of foods to extend shelf life. Palm oil, for example, is used in nearly 20% of all goods sold in Swiss supermarkets (Bundesamt für Umwelt, 2015), despite having enormous ecological production costs (Butler & Laurance, 2009). To address this, consumers have the option to choose foods with sustainability certification (i.e., "eco-labels"). For example, choosing products with the RSPO label or the UTZ label ensures the low environmental impact of consumers' palm oil, cacao, and coffee purchases. Considering

consumers' claim to be willing to pay for eco-labeled products (Galarraga Gallastegui, 2002), boosting the currently low market impact of these products can be a driver of sustainable development.

1.3. Factors influencing environmentally friendly food choices

Although references such as the PHD illustrate how a shift toward more environmentally friendly food choices can be accomplished, providing such information alone will not be enough to result in a large-scale change in consumer behavior. This is because food choice is highly complex, as it is influenced by food-, individual-, and society-related factors, according to a model by Chen and Antonelli (2020) (see Figure 4).

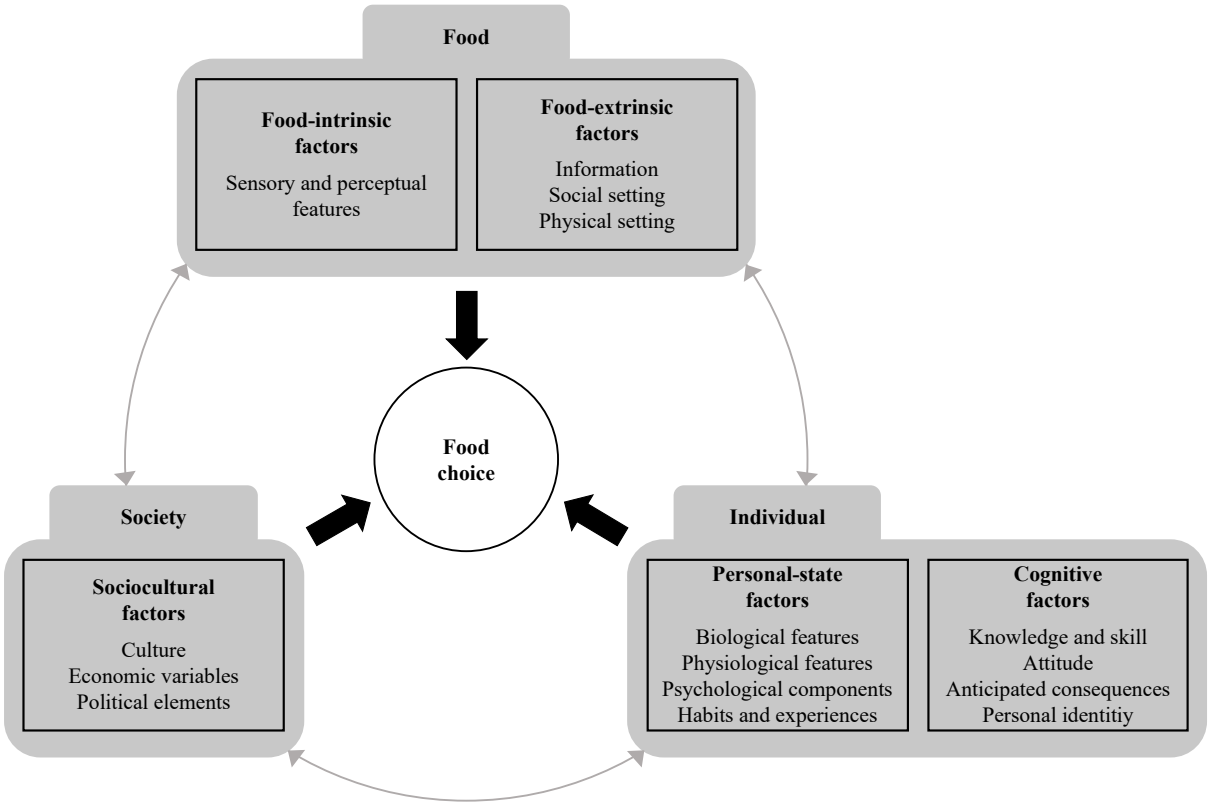

Figure 4. Factors that influence food choice based on a model by Chen and Antonelli (2020).

Based on this model, the following describes how *food-intrinsic*, *food-extrinsic*, *personal-state*, *cognitive*, and *sociocultural factors* impact consumers' motivation and ability to choose environmentally friendly foods

1.3.1. Food-related factors

Food-intrinsic factors that influence food choice are features of a food itself, such as sensory (e.g., flavor, taste, smell, and texture) and perceptual (e.g., color, portion size, and quality) factors. Since taste is often consumers' main criterion for food choice (Scheibehenne et al., 2007; Schulte-Mecklenbeck et al., 2013), sensory and perceptual factors can sometimes interfere with one's motivation and ability to choose environmentally friendly foods. The public's sensory perception of conventional meat vs. alternative proteins is a fitting example of this: Meat is perceived as delicious and one of the most enjoyable foods (Kemper & White, 2021; Piazza et al., 2015; Pohjolainen et al., 2015). In contrast, meat substitutes, such as tofu or vegetarian burgers, are perceived as being less tasty, less filling, and inferior in terms of texture compared to conventional meat (Michel et al., 2021). Insects are even viewed by most Western consumers as disgusting (Hartmann & Siegrist, 2017b). As taste perceptions will always be a priority, they are detrimental to the extent to which new eating habits are adopted.

Food-extrinsic factors that influence food choice include information "around" the food (e.g., labels, claims, packaging, and advertising), physical environment (e.g., a buffet or retail environment), and social setting (e.g., eating alone vs. with others). Among these factors, labels are often assumed to be essential for promoting environmentally friendly food choices (European Commission, 2019). However, many eco-labels have only a limited impact on consumers' purchases, even when consumers claim to be concerned about specific food sustainability issues and thus wish to buy eco-labeled products (Horne, 2009). This inconsistency between consumers' intentions and actions has various causes, such as their lack of knowledge on and willingness to pay for eco-labeling (Grunert et al., 2014; Liu et al., 2017). Regardless, the effectiveness of such informational tools and potential alternative "sustainability signalers" can have a substantial impact on transforming consumers' food choices.

1.3.2. Individual-related factors

Personal-state factors that influence food choice are biological features (e.g., genes, metabolism, and health), physiological features (e.g., hunger, appetite, and weight), psychological factors (e.g., emotion, motivation, and personality), and habits and experiences. Because many of these factors have evolved to benefit human survival, they do not always facilitate environmentally friendly food choices. While food neophobia (i.e., the reluctance to adopt new foods), for instance, can be a protective mechanism, it also contributes to consumers' mistrust of potentially beneficial technologies. Hereby, consumers act on an affect

heuristic: Since they lack knowledge about most novel technologies, they rely instead on affect to form a judgment (Siegrist & Hartmann, 2020a). For example, as biotechnology and cultured meat elicit negative associations (e.g., "manipulation of nature") (Bryant & Barnett, 2020; Connor & Siegrist, 2011), consumers' overall judgment of these technologies is skeptical. Considering how deeply ingrained these affect-based mechanisms are, they are bound to impact the extent to which society adopts novel, sustainable foods.

Cognitive factors that influence food choice include an individual's food-related knowledge and skill (e.g., concerning nutrition or cooking), attitude (e.g., a belief that a sustainably produced diet is important), anticipated consequences (e.g., benefit vs. risk), and personal identity (e.g., vegetarianism or religion). Various misconceptions exist concerning the meaning of eco-labels (Grunert et al., 2014), the environmental impacts of animal protein vs. alternative proteins (Hartmann at al., 2022), the benefits and risks of novel food technologies (Connor & Siegrist, 2010), or the attributes that determine a food's sustainability (Hartmann et al., 2021), for instance. The prevalence of such knowledge gaps is a limiting factor in the degree to which the public's consumption patterns can be transformed.

1.3.3. Society-related factors

Sociocultural factors that influence food choice include economic variables (e.g., income, socioeconomic status, and price), political elements (e.g., agricultural and food policy regulations), and culture (e.g., norms, values, beliefs, and traditions). Indeed, the extent to which individual consumers are motivated and able to engage in different sustainable consumption practices often depends on their sociocultural surroundings. The "base line" willingness to eat insects, for example, varies greatly between cultures. Within some communities of Asia, Africa, and South America, insects are (or were, until recently) an established source of protein. Although entomophagy is not as common among these countries' newer generations (Yen, 2015), exposure to entomophagy traditions increases the chance that the practice may regain popularity, driven by environmental motivations. In contrast, many Western societies have always considered entomophagy taboo because they associate insects with dirt and disease (Mancini et al., 2019). As a result, some researchers consider it highly unlikely that the practice will soon become established among Western consumers (Dagevos, 2021). Thus, it needs to be considered that for all the pro-environmental behaviors discussed in this dissertation, sociocultural context matters, and a one-size-fits-all perspective, therefore, may not be realistic.

1.4. Topics of the current dissertation

In light of the grave consequences and challenges of our global food system, a fundamental transformation of consumers' food choices is necessary. Out of the various food-related behaviors that impact our environmental footprint, the current dissertation focuses on consumers' approaches to composing meals, their awareness of eco-labels, and their acceptance of alternative proteins. Specifically, this dissertation encompasses four central research questions (presented in Table 1) that address knowledge gaps related to these topics.

Table 1. Overview of this dissertation's chapters, topics, and research questions.

Chapter	Topic	Central research question
1	General Introduction	
2	Topic 1: Environmentally friendly meals	What are consumers' approaches to composing an environmentally friendly meal?
3	Topic 2: Palm oil and the RSPO label	How aware and concerned are consumers about palm oil and the RSPO label?
4	Topic 3: Insects as food	What factors correlate with consumers' willingness to consume (WTC) insects?
5	Topic 4: Microalgae (MA)	What product attributes increase consumers' acceptance of novel MA-based foods?
6	General Discussion	

1.4.1. Topic 1: Consumers' approaches to composing environmentally friendly meals

Meals are key eating occasions in our daily lives. Thus, the way we habitually compose our meals greatly determines our environmental footprint. In recent years, many consumers have become more aware of this, and claim to have adopted some (so-called) climate-friendly food choices, such as incorporating more seasonal and regional foods into their diets (Tobler et al., 2011a). However, there is still room for improvement, especially concerning the persistently high intake of animal-based foods. Driven by hedonistic attitudes, many consumers are unwilling to eliminate meat from their diets (Schösler et al., 2012) and continue to consume large amounts of dairy (see Figure 2). Identifying inconsistencies in consumers' behaviors vis-

à-vis their knowledge of sustainable food choices will rely on a more profound understanding of consumers' approaches to composing environmentally friendly meals.

The food choice mechanisms that go into composing a meal are complex, as they involve multiple different considerations about what and how much to eat. For instance, a meal tends to be based on three main components (grains + vegetables + meat/fish), sometimes includes additional foods (e.g., side dishes, and desserts), and may be eaten in a specific social setting (e.g., at home, a cafeteria, or a buffet). Furthermore, food choices are not entirely based on rationality but instead on heuristics—mental "rules of thumb" that allow us to make quick yet reasonable decisions (Gigerenzer & Goldstein, 1996; Kahneman et al., 1982). During meal composition, heuristics are especially important, as we are faced with many food-related decisions that need to be made in a short amount of time. Consider, for example, someone at a large buffet: Instead of analyzing information on all the food options, the individual may simply choose the foods most familiar to him or her. Using this familiarity heuristic can save people time and mental effort because it allows them to compose a meal that is "good enough."

Although meal composition (and many other daily food choices) is typically guided by heuristics (Schulte-Mecklenbeck et al., 2013), not much is known about the heuristics that consumers use to compose environmentally friendly meals. So far, research has shown that consumers perceive foods that are organic, seasonal, regional, "natural," healthy, and lack excessive packaging as environmentally friendly (Bosona & Gebresenbet, 2018; Lazzarini et al., 2016; Lazzarini et al., 2017; Tobler et al., 2011b; Wallnoefer et al., 2021). To investigate the extent to which these food attribute perceptions also translate into heuristics for composing an environmentally friendly meal, it could be conducive to place test persons in a "real-life" meal composition situation and make them verbalize their decision processes. For example, having participants choose a meal from a fake food buffet and letting them "think aloud" is a methodology that can effectively reveal consumers' strategies for food selection (Bucher et al., 2011; Fink et al., 2021).

To this end, Chapter 2 presents a study that investigates how and why Swiss consumers choose foods when they are prompted to compose an environmentally friendly meal at a fake food buffet. Hereby, consumers' food choices and food choice reasons are interpreted in terms of heuristic decision-making. The study aims to reveal some of the consumers' misconceptions and biases surrounding environmentally friendly food choices, as this is fundamental to transforming current consumption patterns.

1.4.2. Topic 2: Consumers' concern and awareness of palm oil and the RSPO label

Because countless processed food products sold in supermarkets contain unsustainably produced ingredients (e.g., certain vegetable oils), the environmental impact of grocery purchases can easily accumulate. About every fifth product in Swiss supermarkets, for example, contains palm oil (Bundesamt für Umwelt, 2015), a fat that is controversial for many reasons. Most prominently, palm oil production is responsible for a high degree of ecological damage, such as deforestation, loss of biodiversity, and degradation in soil quality (Butler & Laurance, 2009; Wilcove & Koh, 2010). The palm oil industry has also been linked to problematic social issues regarding exploitative and inhumane plantation labor conditions, as well as the eviction of locals from their traditional lands (Carrere, 2001). Also, various health detriments have been associated with excessive palm oil consumption (Sacks et al., 2017; Sun et al., 2015).

Consumers can avoid such unsustainably produced foods by increasing their purchases of eco-labeled products. The RSPO label, for example, is meant to signal that a product contains environmentally friendly and socially beneficial palm oil. However, even though many consumers report substantial concerns about specific food issues and thus claim to be interested in buying eco-labeled products, this is not always apparent in their purchase behaviors (Grunert et al., 2014; Horne, 2009). Since this concern–behavior gap is a problem that is observable across many types of eco-labels, some researchers question the overall usefulness of sustainability certification schemes (Pedersen & Neergaard, 2006).

Although a large body of research has demonstrated that consumers are greatly concerned about palm oil (e.g., Verneau et al., 2019), few studies have investigated how this translates into consumers' use of palm oil-related labels, such as the RSPO label. These studies have shown that, while interest and a willingness to pay for sustainably produced palm oil exist (Borrello et al., 2019; Reardon et al., 2019), the public appears to be largely unfamiliar with the RSPO label (Ostfeld et al., 2019). These findings indicate that there may be a lack of recognition of the RSPO label, which is a key prerequisite for the success of any eco-label (Grunert et al., 2014).

To this end, Chapter 3 explores consumers' concern and awareness of palm oil and the RSPO label, serving as a case study of the mechanisms that contribute to the public's low reliance on eco-labeling. Understanding these mechanisms will be beneficial for assessing the current effectivity of and formulating implications for the market's current "sustainability signalers" (e.g., eco-labels), which aim to facilitate consumers' pro-environmental purchases.

1.4.3. Topic 3: Factors correlated with consumers' WTC insects

To shift toward more environmentally friendly consumption patterns, a wide-scale substitution of animal-based foods in favor of alternative food products is necessary. While many alternative proteins can be considered relatively novel foods (e.g., extruded meat analogues or cultured meat), insects do not fall into this category, as these invertebrates have been part of the human diet for millennia. The current contribution of insects to the global food system, however, is only a small fraction compared to domesticated animals. In most of the Western world, eating insects (i.e., entomophagy) is uncommon and considered taboo (Mancini et al., 2019). Moreover, populations that practice entomophagy (e.g., in Africa, Central and South America, and Asia) tend to eat insects in relatively small amounts (e.g., as snacks) (Govorushko, 2019). To tap into the full potential of insects as a significant global protein source, promoting entomophagy will require a two-pronged approach: a boost in awareness in Western countries, and the mainstreaming of diets with insects as a bulk-source of protein (Van Huis et al., 2013).

Increasing the world's consumption of insects has benefits for human health, the environment, and society. First, insects are high in essential nutrients and contain more protein than many conventional food commodities derived from vertebrate animals (e.g., beef, chicken, and fish) and even plants (e.g., soybeans and maize) (Payne et al., 2016). Second, insect farming requires far less land and water and emits far less greenhouse gases and ammonia than livestock farming does (Halloran et al., 2016; Smetana et al., 2015). Lastly, insects can be farmed using low technology, with little capital investment, and on non-agricultural land. Thus, it is achievable for smallholders (i.e., those who have small farms operating under small-scale agriculture models) in rural and urban regions and could represent a viable pathway to poverty alleviation in these communities (Govorushko, 2019).

Since the practice of eating insects is both age-old and controversial, its acceptance has triggered many researchers' attention. Numerous studies have been conducted on this subject (e.g., Dagevos, 2021) and have shown that, especially in Western countries, food neophobia and disgust are the main barriers to consumer acceptance. In contrast, the WTC insects can be increased by educating consumers about and exposing them to entomophagy, improving the sensory experience of insect-based foods (e.g., camouflaging insects in foods in terms of taste and appearance), and positively framing insect-based foods (e.g., emphasizing the benefits of entomophagy).

Reviewing and synthesizing this large body of literature could greatly promote entomophagy by identifying universal trends and gaps in research. Thus far, reviews of past

entomophagy studies have been qualitative (based on description, e.g., a narrative review) (e.g., Dagevos, 2021; Hartmann & Siegrist, 2017b; Mancini et al., 2019), not quantitative (based on statistics, i.e., a meta-analysis). However, a meta-analytic review has a specific advantage over a qualitative review which could greatly enhance our understanding of a specific topic: Specifically, a meta-analysis generates a quantitative estimate ("mean effect size") of a studied phenomenon. For example, it would be possible to calculate a mean effect size for the WTC insects based on many different studies. Based on such a quantitative measure, the highly varied results on this topic, which have resulted from entomophagy being a globally studied and controversial phenomenon, could be clarified more easily. As another benefit, a reviewer's subjectivity is less likely to impact a meta-analysis as compared to a qualitative review (Guzzo et al., 1987). This would be especially conducive to exploring a divisive topic like entomophagy acceptance, as a researcher's characteristics (e.g., culture, or disgust sensitivity) may sway the "base line" attitude toward such a subject. Although the meta-analytic approach also has shortcomings (e.g., publication bias) (Guzzo et al., 1987), it offers an untapped perspective on societies' current entomophagy acceptance.

To this end, Chapter 4 presents a meta-analysis of the correlates of the WTC insects that have been reported in previous studies. By identifying the trends and gaps in previous research via a meta-analytic approach, the analysis aims to bring more clarity to our understanding of this widely studied subject. This is essential to promoting the environmentally friendly yet controversial practice of eating insects.

1.4.4. Topic 4: Product attributes that increase consumers' acceptance of novel MA-based foods

Improving the environmental friendliness of the global food system cannot be achieved through advances in conventional production methods alone (Willett et al., 2019). Thus, a widespread paradigm shift toward adopting novel technologies is imperative to achieving any necessary changes. One of these promising future protein sources is MA. While *macro*algae (also known as seaweed) have been harvested and widely consumed for centuries, MA are single-celled organisms that are currently underrepresented in the food system. Until recently, MA were consumed by humans only in the form of supplement powder that has supposed health benefits. At this point, however, technological advancements have made it possible to produce MA biomass on a large scale, creating the potential for MA to be an innovative ingredient in various food products (Caporgno & Mathys, 2018).

Widespread adoption of novel MA-based food products could benefit humans and the planet. First, MA can have positive effects on human health because it is rich in high-quality proteins and other nutritional compounds (Canelli et al., 2020). Second, MA cultivation is sustainable, as it requires minimal amounts of freshwater and much less land compared to animal-based and even many plant-based proteins (e.g., soybean, pulse legumes, wheat, or pea) (De Vries & De Boer, 2010; Smetana et al., 2017). Lastly, MA can be cultivated on nonagricultural land (e.g., on rooftops, in basements, and even in consumers' homes) (Caporgno & Mathys, 2018) and could, thus, contribute to rising protein demands in our increasingly urbanized world.

For the introduction of novel MA-based food products, Asia could be a promising "first adopter" market. First, since many Asian countries had pronounced population growth and urbanization trends, they would gain enormously from the feasibility of urban MA cultivation. Second, Asian cuisine features many foods like MA (e.g., nori, wakame based on seaweeds), and plant-based protein products (e.g., tofu, or tempeh). Asian consumers' familiarity with plant-based foods and eating patterns could therefore accelerate their acceptance of novel alternative protein products (Hoek et al., 2011). Third, technology-adept Asian consumers appear to more open to novel food production approaches, such as functional foods (Siegrist et al., 2015) or cultured meat (Bryant et al., 2019; Chong et al., 2022; Siegrist & Hartmann, 2020b) in comparison to an average Western consumer, making them ideal target consumers of novel MA-based products.

Although Asia is a prospective market for MA-based foods, little is known about the factors that could impact Asian consumers' acceptance of these novel food products. This is because most consumer research on MA and alternative proteins has been conducted in Europe and North America. According to these studies, most Western consumers have never heard of MA and are skeptical about its sensory appeal (Grasso et al., 2019; Lafarga et al., 2021). Although MA is perceived more positively than insects and cultured meat (Grasso et al., 2019), there is a general reluctance to replace conventional meat with any alternative protein amongst most Western consumers (Hartmann & Siegrist, 2017a; Onwezen et al., 2021). However, it is questionable to what extent these findings for Western consumers are generalizable to the Asian context, considering the large dichotomy of oriental vs. occidental cultures in terms of diet- and food-related concerns (Januszewska et al., 2011; Sproesser et al., 2018).

To identify the factors that affect Asian consumers' acceptance of MA, Chapter 5 presents an online study conducted on a Singaporean sample. Specifically, this study investigates which attributes of a novel MA-based product may increase the acceptance of

novel MA-based food products among Singaporean consumers. The findings can serve as a blueprint for an alternative protein product tailored toward consumer preferences in Asia, and will, hopefully, contribute to more sustainable consumption patterns in this vast market.

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Chapter 2

Environmentally Friendly Meals

The role of heuristics for composing an environmentally friendly meal

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Abstract

Our food choices have a large negative impact on the environment. To address this, it is necessary to understand consumers' environmentally friendly food selection behavior. To this end, we investigated the role of heuristics (i.e., decision-making shortcuts) for a consumer's ability to compose an environmentally friendly meal. Participants (N = 169) were instructed to compose either a meal to their liking (control group) or an environmentally friendly meal (eco group) from a fake food lunch buffet while verbalizing their thoughts ("Think Aloud" method). The groups' meals were compared concerning their environmental impact (LCA data), weight, calories, macronutrients, and food selection reasons. The eco group's meals were lower in environmental impact as compared to the control group. For this, they appear to have followed three approaches which one could interpret as heuristics. In comparison to the control group, the eco group chose (1) less meat and fish (in particular, steak), (2) more meat substitutes (in particular, falafel), and (3) foods that were regional, seasonal, and organic, instead of choosing foods based on perceived tastiness and visual appeal. A regression analysis showed that consumers' knowledge about the environmental friendliness of food significantly predicted the environmental impact of the meals. To further improve the environmental friendliness of their meals, the eco group could have selected less animal-based foods (including egg and dairy), and more plant-based foods (including novel meat substitute products) instead. Furthermore, they appear to overestimate the role of regionality, seasonality, and organic production method, as well as underestimate the role of food amount in the context of food environmental friendliness.

2.1. Introduction

Our daily food choices have a strong impact on the environment and climate change. Even the ways in which we compose a single meal has a significant impact in this regard (Visschers & Siegrist, 2015). The scientific evidence hereby is unanimous: The best approach to reducing the environmental impact of one's diet is to eat less foods of animal origin. In turn, the consumption of foods of plant origin should increase (Aiking, 2011; Frehner et al., 2022; Lamb et al., 2016; Leip et al., 2015).

Even though the interest in improving dietary environmental friendliness has grown in recent years (Siegrist et al., 2015), it does not appear as though consumers have the necessary knowledge to translate this intention into behavior. Specifically, consumers have repeatedly shown that they have very limited knowledge of the environmental impact of different foods (Hartmann et al., 2022; Hartmann et al., 2021; Kim & Schuldt, 2018; Kusch & Fiebelkorn, 2019; Tobler et al., 2011). Most importantly, their awareness about the unsustainability of animal products, as well as their acceptance of plant-based meat alternatives, is low (Estell et al., 2021; Hartmann & Siegrist, 2017; Hoek et al., 2011), even though the consumption of these products immensely impacts the environmental friendliness of one's diet.

2.1.1. Food choices in a "real-life" setting

While past studies have identified the general knowledge gaps and processes linked to a consumer's environmentally friendly eating behavior, not much is known about consumer behavior on this topic from a more practical perspective. Specifically, more research is needed on the consumer's environmental impact perceptions of individual food categories and products, how these perceptions interact, and how this translates into behavior in real-life food choice settings. Gaining a deeper understanding of this is necessary for identifying the concrete barriers hindering consumers from environmentally friendly behavior and developing corresponding targeted interventions. Thus, the current study aims to assess the consumer's environmental food choices in an experimental setting that imitates a real-life food choice situation: the selection of a lunch meal at a buffet. For this, a fake food buffet (FFB) was utilized, which is a reliable and valid method for assessing food choices under well-controlled conditions (Bucher et al., 2012). This means that the amounts of food served from such a fake buffet are comparable to the amounts of food served from a corresponding "real" buffet containing the same selection of foods, and that participants serve themselves portions in relation to their individual energy needs.

2.1.2. Food choice heuristics

So far, the FFB has been used to investigate how healthy meals are composed. Consumers composed healthier meals when they were presented with more (vs. less) vegetable options (Bucher et al., 2011), when they were tasked to compose a colorful (vs. a "typical") meal (König & Renner, 2019), and when they were tasked to compose a meal meant for themselves (vs. a meal meant for others) (Sproesser et al., 2015). Furthermore, participants reduced sweets and desserts in favor of fruits when they were trying to compose a healthy meal (Bucher et al., 2011).

However, participants did not share their thought processes during the meal selection in any of these studies. Thus, they give little insight into an important mechanism of human decision-making: simple heuristics. Humans tend to be frugal about the energy and time invested in decision-making. Thus, instead of taking all available information into account, they often base their choices on single cues that act as simple, yet reasonably effective "rules of thumb" (Gigerenzer & Goldstein, 1996; Kahneman et al., 1982). While these heuristics do not always lead to "the best" choice, humans are inclined to use heuristics because they facilitate making a choice that is "good enough" with minimum effort.

Heuristics guide many of our daily food choices (Schulte-Mecklenbeck et al., 2013). Scheibehenne et al. (2007) demonstrated this by presenting participants with pictures of meals, as well as the meals' attributes (e.g., price, calories, macronutrients, etc.). They found that, instead of aggregating the information of all the significant attributes, participants chose the meal that had the highest value on the attribute that was perceived most important. On average, this "most important" attribute was, in fact, the appearance of the meal, since the meal picture was the cue that received the most attention. Hereby, a consumer's reliance on sensory information for making choices is likely associated with appeasing their most dominant food choice motive: taste (Scheibehenne et al., 2007; Schulte-Mecklenbeck et al., 2013). Indeed, other sensory cues associated with finding the "tasty option" include the product name (Irmak et al., 2011), the packaging color (Mai et al., 2016), or other inherent sensory attributes of a food, e.g., smell or perceived tastiness (Schulte-Mecklenbeck et al., 2013).

In certain situations, consumers will combine different heuristics, for example in a sequential manner (Leong & Hensher, 2012). Consider, for example, someone at a buffet. The first "mental shortcut" this individual is inclined to take is the use of a hedonistic heuristic, e.g., focusing solely on the visual (taste) appeal of the options while ignoring any other available information. The second shortcut taken may then be the use of a dichotomous heuristic, which involves a binary categorization of foods as either "looking tasty" or "not

looking tasty." Such binary classifications ("good" vs. "bad," "tasty" vs. "un-tasty," or "healthy" vs. "unhealthy") are principles guiding our food choice behavior (Carels et al., 2007; Chernev, 2011; Rozin et al., 1996; Rozin & Holtermann, 2021). In a last step, the individual at the buffet may apply a prototype heuristic (Kahneman & Frederick, 2002) to further simplify the decision process. The mental prototype (i.e., the "best example") for tasty foods appears to be foods that are high in fats or sugar (e.g., cookies, junk food) (Locher et al., 2005), whereas a prototype for un-tasty foods appear to be plant-based, low fat foods (e.g., spinach, kale) (Locher et al., 2005).

While hedonistic motives and heuristics appear to be the "default" for most of our food choices, consumers apply different heuristics when they choose foods for utilitarian reasons (e.g., health and weight management, environmental conservation) (Botti & McGill, 2011). When consumers are trying to choose healthy foods, for example, findings suggest that consumers make use of heuristics like "tasty foods = unhealthy foods" (Mai & Hoffmann, 2015), "light foods = healthy foods" (Heuvinck et al., 2018), "colorful meals = healthy meals" (König & Renner, 2018), or "health-labelled foods = healthy foods" (Fagerstrøm et al., 2021). Specifically, these studies show that consumers will use these cues as main indicators of the healthiness of foods. As Machín Antúnez et al. (2020) note, some of these heuristics are not necessarily related to nutrition information relevant to the healthiness of foods.

Although there is extensive literature on heuristics for identifying supposedly healthy foods, not much is known about heuristics concerning environmentally friendly foods. There are certain food characteristics that consumers commonly associate with environmental friendliness, such as the use of organic production methods (Bosona & Gebresenbet, 2018; Petrescu & Petrescu-Mag, 2015; Siegrist & Hartmann, 2019), regionality (Annunziata & Mariani, 2018; Aprile et al., 2016), seasonality (Siegrist et al., 2015; Wallnoefer et al., 2021), perceived naturalness and healthiness (Hartmann et al., 2022), or the perceived level of excessive packaging (Tobler et al., 2011). It appears that some of these characteristics translate into "rules of thumb" that consumers use when aiming to select environmentally friendly foods (Lazzarini et al., 2017). To investigate this further, the current study utilizes the FFB in combination with a "Think Aloud" methodology, a research method in which "participants speak aloud any words in their mind as they complete a task" (Charters, 2003, p. 68). Naturally, this tool is helpful for gaining insights to cognitive processes, such as food decision-making (Fink et al., 2021; Ogden & Roy-Stanley, 2020), and is thus suitable for identifying food choice heuristics.

2.1.3. Study aims

Although consumers express interest in eating more environmentally friendly foods, they are often unsuccessful in translating this intention into behavior. To bridge this gap, it is first necessary to understand how consumers typically approach making more environmentally friendly food choices. For this, we analyzed participants' food selection and food selection reasons as they composed a meal from a FFB whilst they verbalized their thoughts. The aim of this study was to identify potential heuristics consumers use for selecting environmentally friendly foods, and the role these heuristics have for consumers' ability to compose an environmentally friendly meal.

2.2. Methods

2.2.1. Sample

Participants were recruited through the Consumer Behavior panel, different webpages, and e-mail. Participants had to be at least 18 years old, speak German fluently, and not suffer from any food allergies or intolerances. Each participant was rewarded with 20 CHF for their participation in this thirty-minute-long study. Overall, 169 participants took part, of which approximately half were female (52%), and had an applied university or university degree (48.5%), with a mean age of 33 years (SD = 12). The mean Body Mass Index (BMI) at 22.57 (SD = 2.91) fell within the "normal" range. Before the experiment started, each participant was informed about the tasks and gave their written consent. The Ethics Committee of the Eidgenössische Technische Hochschule (ETH) Zurich approved the study (EK 2020-N-96).

2.2.2. Experimental procedure

The experiment was conducted at ETH Zurich in late 2020. Participants (N = 169) were equally and randomly divided into two groups: a control group (n = 85) and an intervention group, also called the "eco" group (n = 84). Participants were individually invited into the laboratory room, where they were introduced to an FFB, which consisted of replica food items. The control group was asked to compose a main meal (lunch or dinner) that they would normally eat from the given selections in the buffet, whereas the eco group was asked to compose one which they considered "environmentally friendly." During this, they were asked to verbalize their thoughts while being audibly recorded. Since the buffet did not include sauces, participants were asked to imagine these on top of their assembled meals. They were also asked to imagine that the current season was July/August. Participants answered a pencil-

and-paper questionnaire with questions that included their demographics and attitudes regarding nutrition and ecology. After the experiment, the assembled meals were photographed, and the foods were weighed by food category. The audio recordings were transcribed and encoded. Environmental friendliness for the selected foods/meal was determined by the use of eco-points based on life cycle assessment (LCA) data, which is the result of a specific LCA method. Further methodological details are described in the following paragraphs and elsewhere (Bucher et al., 2011; Bucher et al., 2012).

Think Aloud Methodology.

Participants were asked to verbalize their thoughts during the experimental task as proposed by the Think Aloud methodology (Charters, 2003). This method usually leaves participants to talk freely during the task; however, the researcher conducting the Think Aloud experiment can make use of a protocol containing questions that participants can be asked if they are struggling with thinking aloud. Such an approach was taken for the current experiment. Specifically, if participants struggled with verbalizing their thoughts, the experiment conductor asked questions typical of Think Aloud protocols, e.g., "Why did you choose broccoli? Why did you choose wheat pasta instead of full grain pasta?" (Charters, 2003). The audio recordings of participants talking were transcribed and encoded. Specifically, participants mentioned reasons for choosing foods as well as the food selection sequence (i.e., which food was chosen in 1st, 2nd, 3rd, etc. place) of each participant was recorded. For this—based on all transcriptions—the 10 most frequently mentioned reasons for choosing foods were identified as taste, regionality (Swiss), healthiness, the use of an organic production method, seasonality, familiarity, color, visual appeal, habit, and craving. Then, for each participant individually, the frequency of these reasons was counted, and the sequence of the food selection was recorded. Only the mentioned reasons for choosing foods were recorded, whereas the mentioned reasons for *not* choosing foods—which were very rarely mentioned by participants—were left out of the analysis.

The fake food buffet (FFB).

The FFB method is a validated research tool that enables the investigation of food selection behavior in a buffet setting in a standardized manner (Bucher et al., 2012). The FFB in this experiment (Figure 5) contained 41 different food replica produced by the German company, Döring GmbH (https://www.attrappe.de). Since it was supposed to reflect a typical buffet that can be found in a Swiss canteen, foods from eight different food categories (starchy foods, vegetables, meat, meat substitutes, fish, dairy and egg, fruit, and dessert) were included, as these were shown to be components of an average lunch (Woolhead et al., 2015). The buffet

contained foods with varying degrees of environmental friendliness, based on various food processing degrees (e.g., boiled potatoes vs. French fries), meat and meat-free options (e.g., chicken nuggets vs. tofu), and regional and imported food products (e.g., Swiss apples vs. Ecuadorian bananas). Furthermore, meat substitutes from the brands Beyond Meat, Planted, and Quorn were included. Each food carried labels indicating the name, the origin, whether it was organic, and whether it was vegetarian/vegan. Figure 6 shows an example of a selected meal. The assembled meals were photographed and the foods were weighed by food category.

The weight of the fake foods ("fake food weight") was used to calculate the theoretical weight ("real food weight"), as well as the calorie content, macro nutrient content, and environmental impact of the "real" foods (i.e., the food that the fake food represented). For this, conversion factors needed to be multiplied with the fake food weight. These conversion factors were obtained through the nutritional information of the FFB foods on a food database (https://fddb.info).

Life Cycle Assessment (LCA) and eco-points (EP).

An LCA is the analysis of the potential environmental impact of products during their entire life cycle. Different LCA methods exist. For the current study, the ecological scarcity method was used, which aggregates a broad range of environmental impacts into an easily comparable, one-score impact value measured in eco-points (EP) per unit of quantity (Jungbluth et al., 2012). The more EP there are for a specific food, the more damaging it is assumed to be to the environment. The EP of the foods used in the present study (Figure 7) were provided by the Swiss sustainability consulting company ESU Service Ltd. (https://esu-services.ch) and have been used in previous studies (Hartmann et al., 2021; Lazzarini et al., 2016).

The environmental impact of a meal was calculated as follows: First, the EP for each of the selected food categories was calculated. For this, the "real food weight" of a food (e.g., 50 g of rice) was multiplied by the EP per gram of this food (e.g., rice has 70 EP per 1 g), which are displayed in Figure 7. Then, the EP of all the food in a meal were summed up.

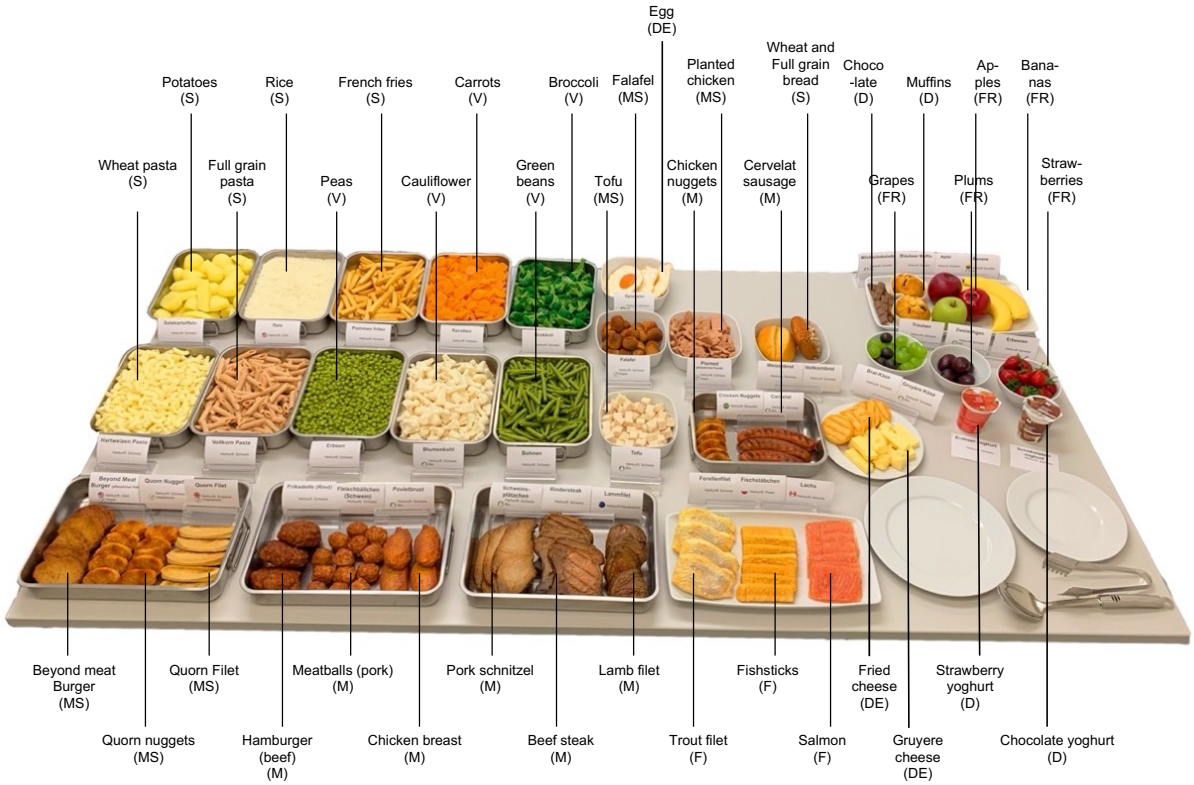

Figure 5. The fake food buffet (FFB). The food categories are S = Starchy foods, V = Vegetables, M = Meat, MS = Meat substitutes, F = Fish, DE = Dairy and egg, FR = Fruit, and D = Desert. Meat substitutes from the brands Beyond Meat, Planted, and Quorn are included.

Meal's EP = 5717
(Pork schnitzel, chicken breast, fried cheese, french fries, broccoli, beans, carrots, muffin, chocolate, grapes)

Meal's EP = 3499
(Falafel, tofu, potatoes, beans, peas, broccoli, carrots, banana, grapes)

Figure 6. Example meals and their environmental impact in eco-points (EP). These meals were chosen as examples because their EP was close to the mean EP of the corresponding group (Control: $M = 6359$, $SD = 6041$; Eco: $M = 3316$, $SD = 2647$).

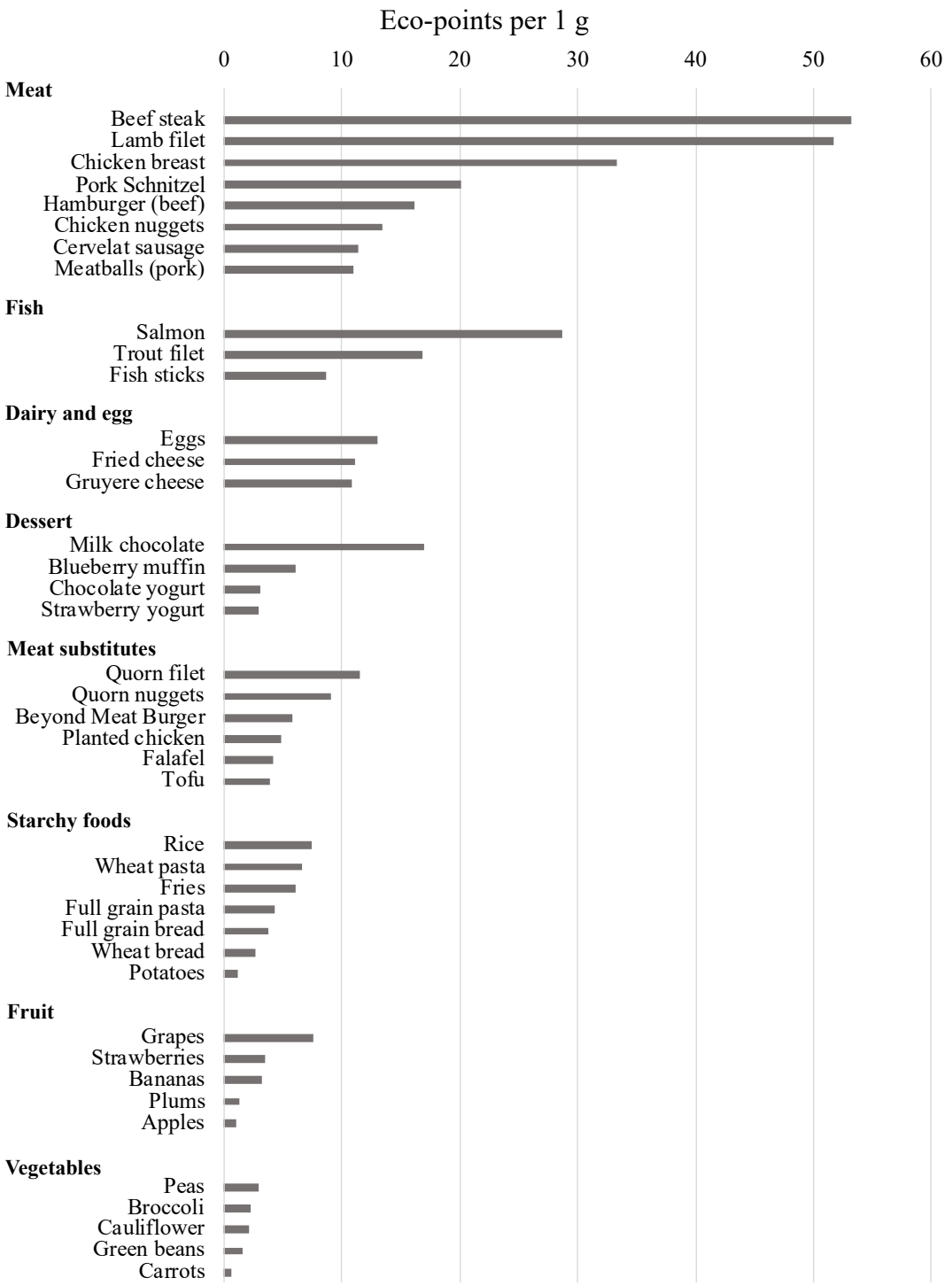

Figure 7. Buffet foods' environmental impact in EP per 1 g. Meat substitutes from the brands Beyond Meat, Planted, and Quorn are included.

The questionnaire.

The questionnaire took approximately 15 minutes to fill out, was in German, and covered self-reported attitudes in relation to demographics, nutrition, and ecology. Next to age

and gender, the educational level was measured and grouped into three categories: low (no education or primary and secondary school), coded as 1; medium (vocational school, high school), coded as 2; and high (applied university, university), coded as 3. The BMI was calculated as the quotient of self-reported body weight (in kilograms) divided by the square of height (in meters).

Knowledge about the environmental impact of foods (abbrev. "knowledge about food environmental impact") was measured with 16 items (Hartmann et al., 2021). Participants were asked 16 multiple choice knowledge questions. An example item is, "Which of the following causes the most environmental impact?" with the answer options being "Storage," "Packaging," "Transport," "Production" (the correct answer), and "Do not know." For each correctly answered item, a participant received one point. Thus, a total of 16 points could be achieved in the knowledge questionnaire.

Concern about health-related food issues (abbrev. "health concern") was measured with four items taken from the General Health Interest subscale (Roininen et al., 1999). Participants were presented with four statements, such as "It is important to me to have a healthy diet," and were asked to indicate their level of agreement on a 7-point scale from "I disagree strongly" (1) to "I agree strongly" (7).

The meal's perceived environmental friendliness was measured with one item constructed for this survey. Participants were asked, "How environmentally friendly do you perceive your chosen meal?" Responses were given on a 6-point scale from "Not environmentally friendly at all" (1) to "Very environmentally friendly" (6).

The meal's perceived tastiness was measured with one item constructed for this survey. Participants were asked, "How tasty would you perceive the chosen meal?" Responses were given on a 6-point scale from "Not tasty at all" (1) to "Very tasty" (6).

Participants' answers to the questionnaire are displayed in Table 2. Here, only the participants' demographic characteristics, and attitudes/behavior related to nutrition and ecology (i.e., age, gender, education, knowledge about food environmental impact, health concern) are shown, serving as a randomization check between groups. The groups did not differ regarding any of these constructs. The items related to the selected meals (i.e., the perceived tastiness and environmental friendliness of the meals) were excluded, as these are discussed in the results section.

Table 2. Characteristics of the study sample.

	Overall sample (N = 169)					Control (n = 85)		Eco (n = 84)		Control vs. Eco		
	Possible range	*M* or %	*SD*	No. of items	Alpha[a]	*M* or %	*SD*	*M* or %	*SD*	*t* or X^2	*df*	*p*
Female (%)		52.00		1		49.00		55.00		0.49	1	.54
Age	19–69	33.00	12.00	1		32.00	12.00	31.00	12.00	0.71	167	.48
Education				1						0.77	2	.68
Low (%)		14.40				17.00		12.00				
Med. (%)		37.10				37.00		37.00				
High (%)		48.50				46.00		51.00				
BMI	9–65	22.57	2.91	1		22.80	2.88	22.35	2.95	0.99	167	.32
Knowledge of the env. impact of foods	1–16	10.72	2.51	16		10.05	2.66	10.68	2.39	1.41	167	.16
Health concern	1–7	5.55	0.95	4	.79	5.54	0.97	5.57	0.94	0.23	167	.82

Note. [a]Cronbach's Alpha.

2.2.3. Data analysis

Analyses were performed using the SPSS statistics software package version 26 (SPSS Inc., Chicago, IL) and R software (RStudio, 2018). A significance level of alpha = .05 was used in the present study. In a first step, the weights of the fake foods were used to calculate various characteristics of the meal as described in previous sections. If a participant had not chosen a specific food, a value of zero was set. These zero values were included when the group means and medians were calculated. Due to the large variability in the environmental impact (Figure 7) and calorie content of foods, there were some meals that had very large and very small values for these variables. In a second step, the data was checked for outliers. Due to the variability in our data, a value was not considered to be an outlier just because it was extremely high or low. Instead, only values that occurred by error were excluded, e.g., during

data entry, data measurement, or during conversion between units. In a third step, assumption testing and corresponding appropriate statistical analyses were conducted. Visual inspection of the data revealed that, for analyses involving the meals' characteristics (e.g., the meal's EP, the meal's calorie content), assumptions for parametric testing were not fulfilled. Therefore, Spearman's rank correlations were used to estimate associations between study variables (Murray, 2013). Furthermore, to compare the meals' characteristics between groups, Mann-Whitney *U* tests were conducted (Table 3). In contrast, analyses involving variables of the questionnaire as displayed in Table 2 (e.g., age, BMI, health concern) fulfilled the assumptions for parametric testing. Therefore, *t*-tests and X^2-test were conducted for these variables to compare the groups. Additionally, X^2-test were conducted to compare the number of meat, fish, and meat substitute products between the groups (Table 4). Lastly, a regression analysis was performed for each group with the environmental impact of the meals in EP as dependent variable, and gender, BMI, knowledge about food environmental impact, and health concern as independent variables. For this, the meals' EP data were logarithmically transformed to de-emphasize the impact of potentially influential cases and to obtain normal distribution and a constant variance of the model's residuals. This transformation produced values of Cook's $D < 1$ (Cook & Weisberg, 1982), and non-significant Kolmogorov-Smirnov and Shapiro-Wilk test results.

2.3. Results

2.3.1. Food selection

Table 3 summarizes the food selection differences between groups. For the EP and calories, the results in this table are visualized in Figures 8 and 9. Inter-correlations between the variables in Table 3 are displayed in the Chapter Appendix in Table 7. In the following, the summarized in Table 3 are discussed in greater detail.

Environmental impact (in EP), calorie content (in kcal), and EP per kcal.

The eco group's meals had a lower environmental impact than the control group's meals (see Table 3 and Figure 8). Granted, the control group's meals were also higher in calories (see Table 3 and Figure 9). This, however, didn't explain the EP differences, since the control group's meals also had a higher EP per kcal, i.e., they selected foods with a "better" EP/calorie ratio.

This group difference in terms of EP is likely related to participants' meat and fish selection. Firstly, the groups differed in terms of *how much* meat and fish they selected: The

eco group selected less meat and fish than the control group in terms of EP and kcal. For all other food categories (e.g., starchy food, vegetables, etc.), the groups did not differ in this regard (Table 3, Figures 8 and 9). It was noteworthy that the control group gained the most calories from meat, whereas the eco group gained the most calories from their meat substitute selection. Secondly, the groups differed in terms of *how* they selected meat and fish: The control group was more likely to put meat and fish as the first food item on their plate, whereas the eco group was more likely to choose starchy foods and vegetables first.

Weight and number of food items.

As can be seen in Table 3, the groups' meals did not differ in terms of weight and number of food items. Both groups selected meals that corresponded to 500–600 g of food and consisted of about nine food items. Nevertheless, there were group differences when looking at the food categories, with the control group selecting more meat and fish in terms of total weight (in g) than the eco group.

Macronutrients.

As can be seen in Table 3, the control groups' meals had significantly more grams of carbohydrates, fats, and proteins. Again, these meal differences appear to be linked to the meat and fish selection, as the control group's meat and fish selection had more proteins and fat as compared to the eco group. Noteworthy was the fact that the meals of the eco group contained more carbohydrates from meat substitute products as compared to the control group.

Table 3. Group differences regarding the meals (left) and the foods included in the meals (right).

Meals				Food categories			
	Control *M (SD)*	Eco *M (SD)*	*U* value, *p* value		Control *M (SD)*	Eco *M (SD)*	*U* value, *p* value
Environ-mental impact (EP)	**6359.12 (6041)**	3316.21 (2647)	2288.5, $p < .001$**	Starchy foods	**264.05 (251.48)**	155.11 (117.98)	2692.5, $p = .006$*
				Meat	**3219.33 (5281.98)**	1118.42 (2354.56)	2950.5, $p = .028$*
				Fish	**1305.58 (2183.77)**	559.22 (1222.25)	3021.5, $p = .028$*
Calories (kcal)	**762.20 (483.91)**	552.25 (229.23)	2650.5, $p = .004$*	Meat	**165.81 (286.65)**	51.24 (119.82)	2907.5, $p = .019$*
				Fish	**90.14 (148.02)**	36.43 (79.71)	2907.5, $p = .019$*
Environ-mental impact per calorie (EP per kcal)	**7.86 (3.69)**	6.21 (4.05)	2494.0, $p = .001$*	Starchy foods	**3.32 (1.66)**	2.54 (1.06)	2295.0, $p = .010$*
Weight (of the "real foods") (g)	589.81 (274.67)	522.12 (212.72)	3135.5, $p = .172$	Meat	**73.69 (109.50)**	32.46 (54.72)	2951.5, $p = .028$*
				Fish	**59.59 (94.75)**	30.70 (62.93)	2951.5, $p = .028$*
				Dessert	**67.45 (78.61)**	38.11 (84.6)	2883, $p = .026$*
Number of food items	9.13 (3.27)	9.38 (3.28)	3325.5, $p = .438$		---	---	---
Carbo-hydrates (g)	**65.94 (31.52)**	55.25 (25.87)	2842.5, $p = .022$*	Starchy foods	**22.20 (21.63)**	11.82 (12.41)	2578.5, $p = .002$*
				Meat-subst.	6.91 (9.75)	**11.70 (12.98)**	2938, $p = .040$*
Fats (g)	**28.89 (22.37)**	20.46 (11.92)	2757.5, $p = .011$*	Meat	**4.28 (8.25)**	1.36 (3.65)	2951.5, $p = .028$*
				Fish	**5.56 (9.69)**	1.87 (4.68)	2953.5, $p = .013$*
Proteins (g)	**54.26 (37.74)**	39.28 (19.15)	2586.5, $p = .002$*	Meat	**17.25 (25.79)**	7.43 (12.66)	2954.5, $p = .029$*
				Fish	**11.59 (18.5)**	6.10 (12.47)	3049.5, $p = .037$*

Note. Mann-Whitney *U* values are referred to. If there was a group difference (control vs. eco), the greater mean was marked bold. "Number of food items" refers to how many of the buffet foods were selected. Only the food categories with significant group differences are shown.
* $p < .05$, ** $p < .001$.

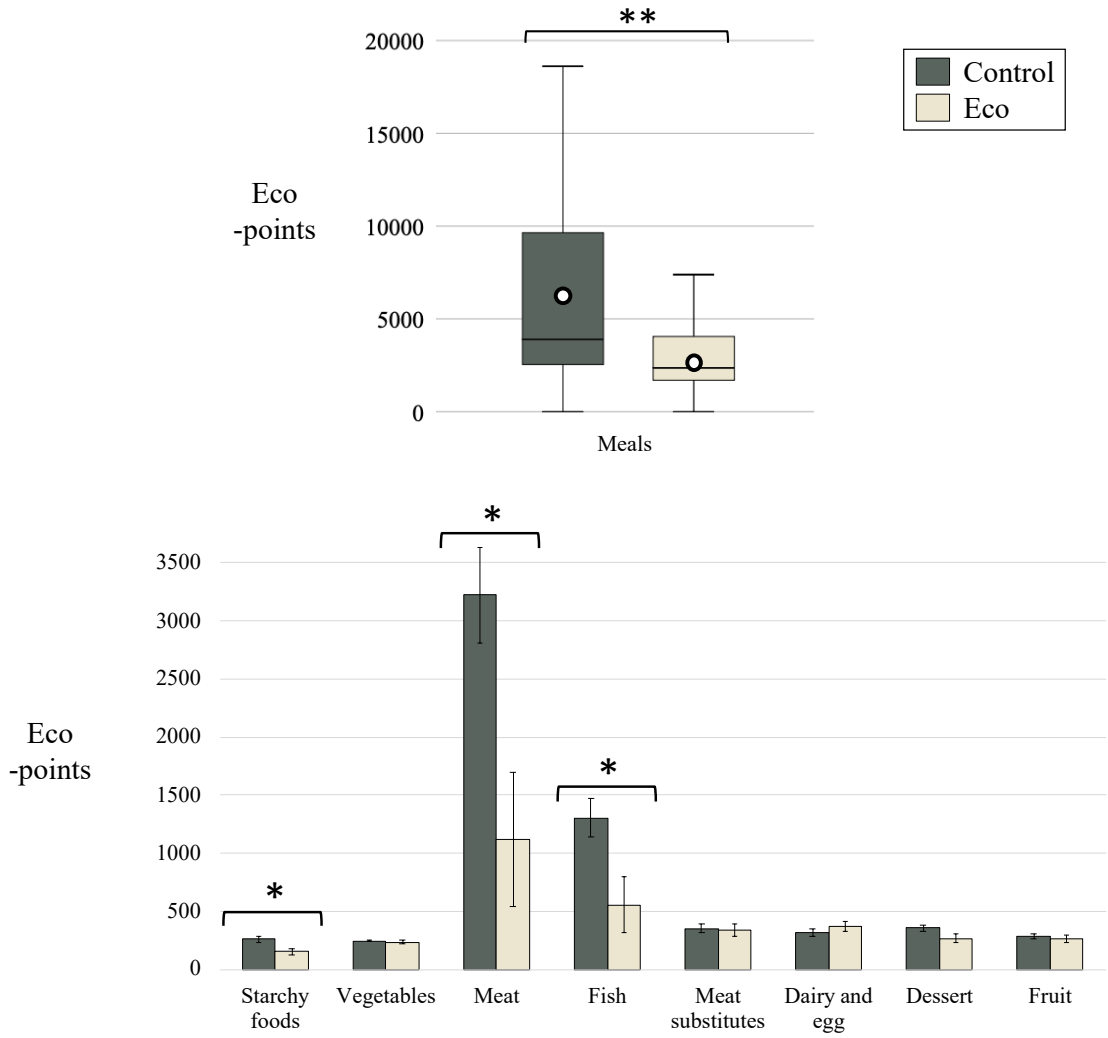

Figure 8. Environmental impact of the meals (top) and the foods included in the meals (bottom). Top: Line within the box represents the median, the circle represents the mean, the box represents the 25th percentiles, the whiskers represent the 95% CI. Bottom: Shown are *M* (*SE*). * $p < .05$, ** $p < .001$.

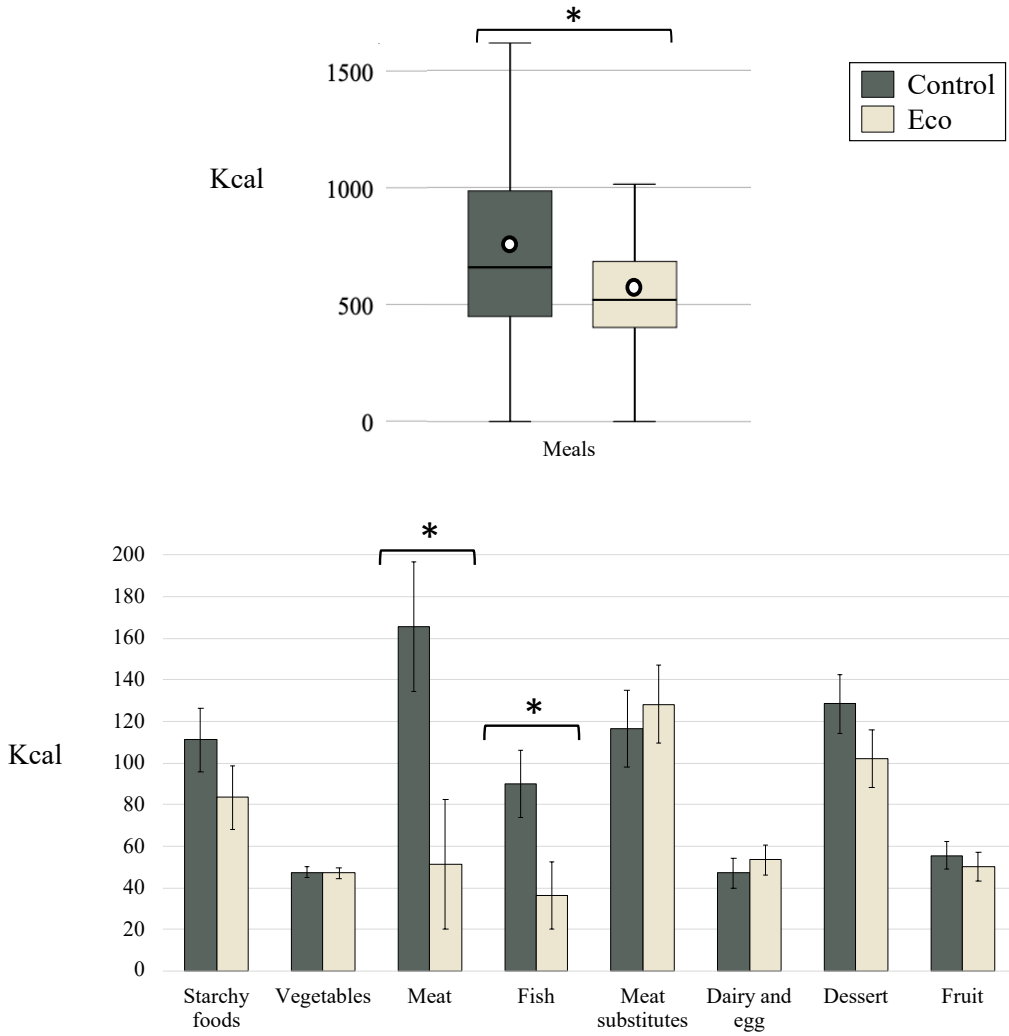

Figure 9. Calorie content of the meals (top) and the foods included in the meals (bottom). Top: Line within the box represents the median, the circle represents the mean, the box represents the 25th percentiles, the whiskers represent the 95% CI. Bottom: Shown are *M* (*SE*). * $p < .05$.

Meat, fish, and meat substitute selection.

Since the groups differed most strongly concerning their meat and fish selection (Table 3), the selection frequency of these food products is displayed in more detail in Table 4. The table also includes the meat substitutes, since these can be used as alternatives to fish and meat. The table confirms that the control group selected more meat (X^2 (1, N = 169) = 14.69, p = .011) and fish (X^2 (1, N = 169) = 9.17, p = .010) products, while the eco group selected more meat substitutes (X^2 (1, N = 169) = 12.95, p = .022). However, these group differences only applied to specific products. Specifically, it was only the beef steak (X^2 (1, N = 169) = 8.84, p = .005) and the salmon (X^2 (1, N = 169) = 13.14, p = .001) of which the eco group chose

significantly less of. Regarding the other nine fish/meat products, the groups did not differ. Regarding the meat substitutes, there were only two products for which there were significant group differences: While the eco group chose falafel more often (X^2 (1, N = 169) = 4.79, p = .033), the control group chose the Beyond Meat Burger more often (X^2 (1, N = 169) = 4.88, p = .047).

Table 4. Frequency of meat, fish, and meat substitute selection.

	Control (n = 85)	Eco (n = 84)	X^2 value (df =1)
Meat	**44**	31	14.70*
Chicken breast	16	18	0.18
Beef steak	**11**	1	8.84*
Lamb fillet	9	2	4.68
Chicken nuggets	3	1	1.00
Pork schnitzel	3	8	2.50
Hamburger (beef)	2	1	0.33
Cervelat (sausage)	0	0	---
Meatballs (pork)	0	0	---
Fish	**35**	18	9.17*
Salmon	**17**	2	13.14**
Trout fillet	14	15	0.84
Fish sticks	4	1	1.82
Meat substitutes	83	**98**	12.95*
Falafel	21	**34**	4.79*
Quorn nuggets	17	25	2.16
Planted “chicken”	14	16	0.19
Tofu	12	18	1.55
Beyond Burger	**11**	3	4.88*
Quorn fillet	8	2	3.75

Note. If there was a group difference (control vs. eco), the greater value was marked bold. The frequencies refer to the number of products selected across the participants of a group (e.g., across all participants in the control group, 21 falafels were selected). * p < .05, ** p < .01.

2.3.2. Food selection reasons and evaluation

Figure 10 displays the most frequently mentioned food selection reasons. The control group chose foods most frequently for taste, whereas the eco group chose regional foods most frequently (i.e., foods labelled to have been produced in Switzerland). Group differences were observable for these variables: The control group chose foods more frequently for taste (U = 1626, p < .001) and visual appeal (U = 2729.5, p < .001) in comparison to the eco group. The eco group on the other hand chose foods more frequently because the foods were labelled as

regional ($U = 1228.5$, $p < .001$), labelled as organic ($U = 2148$, $p < .001$), and were perceived to be seasonal (i.e., seasonal for July/August, since participants had been asked to imagine this being the current season) ($U = 2520.5$, $p < .001$) in comparison to the control group.

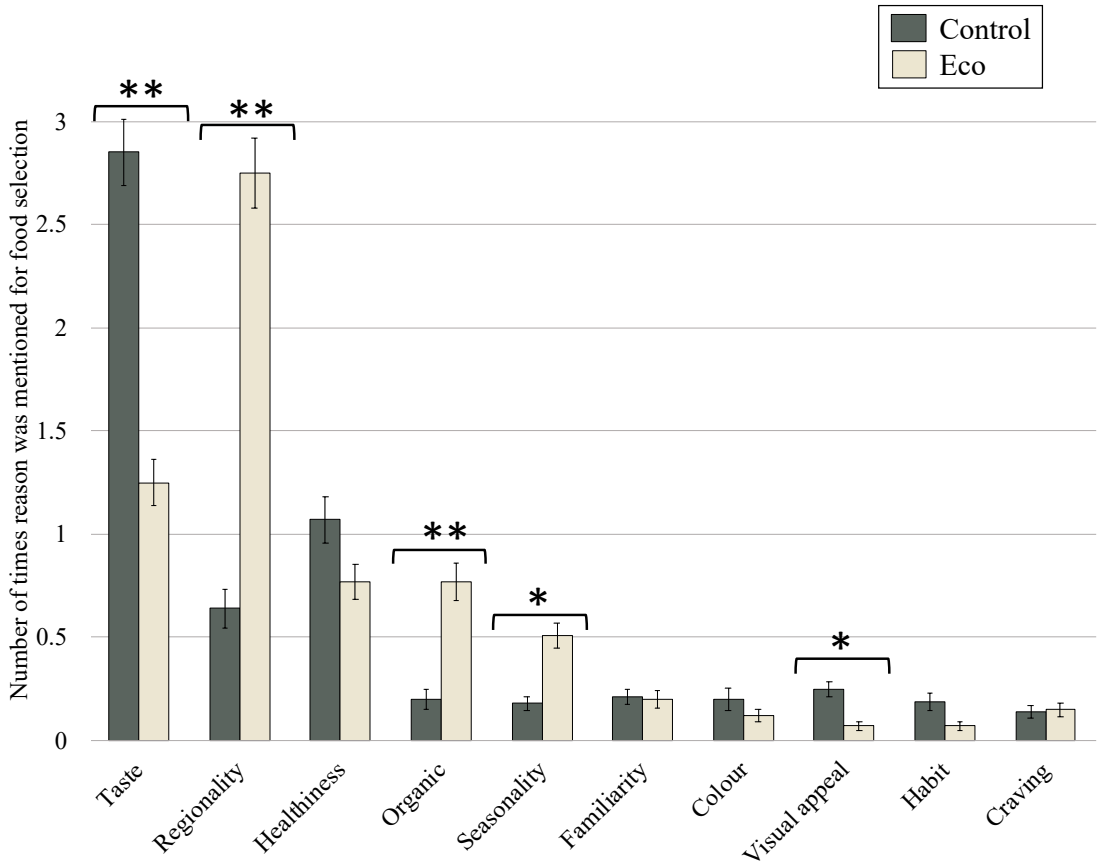

Figure 10. Number of times certain food selection reasons were mentioned. Shown are *M* (*SE*). Displayed are only the most frequently mentioned selection reasons. Regionality refers to the production country being Switzerland. * $p < .05$, ** $p < .001$.

After participants assembled the meals, they rated the meals' environmental friendliness and tastiness. As displayed in Figure 11, the eco group rated their assembled meals as being more environmentally friendly than the control group rated their meals, $t(167) = 4.52$, $p < .001$. There was no group difference regarding the perceived tastiness of the composed meals, $t(167) = 1.90$, $p = .060$.

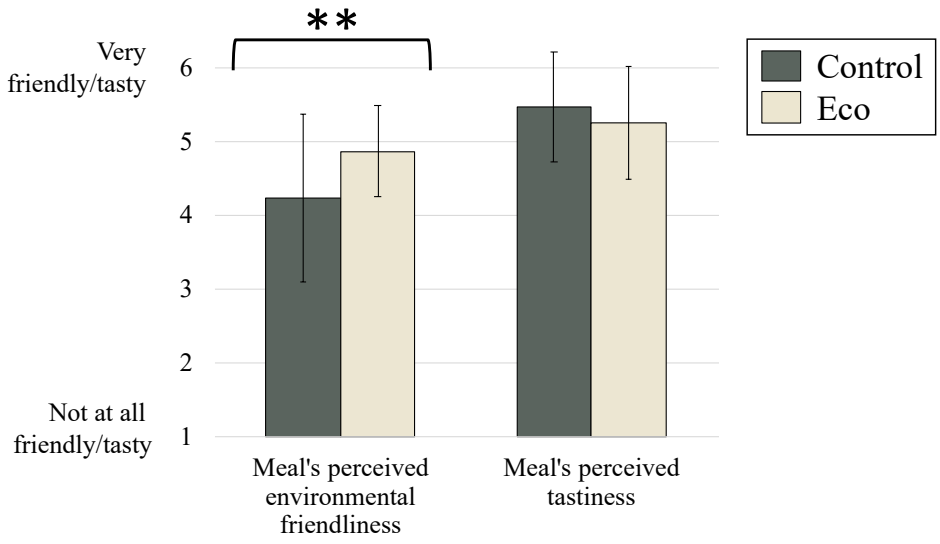

Figure 11. Participants' ratings of the environmental friendliness and tastiness of their own meals. Shown are *M* (*SE*). Participants gave these ratings after they had composed their meal. ** $p < .001$.

2.3.3. Consumer characteristics predicting the environmental impact of the selected meals

Correlations between the study variables are displayed in Table 5. A meal's environmental impact was correlated with the participant's education ($r = -.18$, $p = .023$), BMI ($r = 0.22$, $p = .004$), their knowledge of food's environmental impact ($r = -.20$, $p = .008$), and their perception of their meal's environmental friendliness ($r = -.27$, $p < .001$).

To further investigate these associations, a regression analysis for each group was performed with the environmental impact of the meals in EP as a dependent variable, and gender, BMI, knowledge about food environmental impact, and health concern as independent variables (Table 6). The meals' EP data was logarithmically transformed before running the analysis. The control group's model was significant ($F(4, 80) = 3.68$, $p = .008$), explaining 16% of the variance in the dependent variable, i.e., the meal's environmental impact ($R^2 = .16$). Hereby, meals with a high environmental impact tended to be created by participants with a higher BMI ($\beta = 0.26$, $p = .018$), and a lower knowledge of food environmental impact ($\beta = -0.24$, $p = .028$). Neither gender nor health concern were significant predictors. The eco group's model was not significant.

Table 5. Spearman's rank correlations of study variables.

	1	2	3	4	5	6	7	8	9	10
1 Condition (0 = control, 1 = eco)		-.06	.05	.06	-.08	.10	.03	.30**	-.15	-.31*
2 Age			-.17*	.08	.21**	-.09	.05	.18*	.07	.11
3 Gender (0 = m, 1 = f)				.01	-.35**	-.14	.07	.04	.15	-.13
4 Education					-.09	.11	.16*	.14	.03	-.18*
5 BMI						.05	-.17*	-.14	.08	.22*
6 Knowledge about food environmental impact							< .001	-.02	-.18*	-.20*
7 Health concern								.12	.04	-.04
8 Meal's perceived environmental friendliness									.06	-.27**
9 Meal's perceived tastiness										.07
10 Meal's environmental impact (in EP)										

Note. * $p < .05$, ** $p < .001$.

Table 6. Linear regression with consumer characteristics predicting the logarithmically transformed meal's environmental impact (in EP).

	Control (n = 85)					Eco (n = 84)				
	B	*SE*	β	*t*	*p*	*B*	*SE*	β	*t*	*p*
Constant	7.24	1.08		6.69	< .001	8.40	.78		9.66	< .001
Gender (0 = m, 1 = f)	-0.30	0.17	-0.18	-1.65	.103	-0.01	.15	-0.01	-0.12	.948
BMI	0.07	0.03	0.26*	2.41	.018	0.02	.03	0.11	0.69	.364
Knowledge about food env. impact	-0.07	0.03	-0.24*	-2.24	.028	-0.03	.03	-0.13	-1.04	.267
Health concern	-0.08	0.09	0.10	0.89	.371	-0.10	.08	-0.15	-1.08	.170
	R^2 = .16, F(4, 80) = 3.68, p = .008*					R^2 = .06, F(4, 78) = 1.22 , p = .309				

Note. * p < .05.

2.4. Discussion

Out of the various factors (e.g., biological, cognitive, or social) that influence our food choices, heuristics are important because they allow us to make quick yet reasonable decisions. Thus, the current paper interprets participants' food choices in regard to these "rules of thumb" for decision making. The control group's behavior highlighted that the human "default" meal selection behavior appears to be to choose foods that are perceived as tasty (Scheibehenne et al., 2007; Schulte-Mecklenbeck et al., 2013). In contrast, the eco group's behavior suggests that, when consumers are trying to compose an environmentally friendly meal, they appear to follow three behaviors which one could interpret as heuristic principles: They seem to choose (1) less meat and fish, (2) more meat substitutes, and (3) foods that are regional, seasonal, and organic, instead of choosing foods based on perceived tastiness and visual appeal. Regarding (1) and (2), there were further aspects of the participants' behavior that can be interpreted in the context of heuristic judgement. Specifically, the eco group appeared to have "singled out" specific products to include vs. exclude from their selection. Firstly, the eco group appears to have excluded mainly steak from their selection. Secondly, the eco group was more likely to select falafel (as compared to the control group), but not novel meat alternatives. The following section is a discussion of the extent to which these potential heuristics are effective in terms of increasing dietary environmental friendliness, how consumers could have acquired these heuristics, and how their eco-friendly food choice behavior could be refined and improved.

2.4.1. The eco group composed an environmentally friendly meal

Our first important finding was that the eco group's meals were more environmentally friendly than the control group's meals. This difference persists even when considering the calorie content of the meals, since the eco group's meal had a lower EP per kcal. It was positive to note that, even though the group's meals differed in terms of environmental impact, the groups perceived the tastiness of their meals as being equally high.

2.4.2. The eco group's approaches for composing an environmentally friendly meal

Approach 1: The eco group selected less meat and fish than the control group.

Not only did the control group select more meat and fish as compared to the eco group, they also selected these products as the first food items on their plate, i.e., as the "anchors" of their meals (Marchiori et al., 2014). Since animal-based foods are highly associated with tastiness (Michel et al., 2021), these results are in line with findings that a consumer's most dominant food choice heuristic is hedonistic (Scheibehenne et al., 2007; Schulte-Mecklenbeck et al., 2013). It is possible that the eco group made less choices based on this heuristic since they chose less meat and fish than they would "normally" consume.

However, a look at Table 4 indicates that the eco group seemed to identify two meat products in particular to include vs. exclude in their meals. They chose steak considerably less often than the control group ($n_{control}$ = 11, n_{eco} = 1). In contrast, chicken was chosen by both groups in equally high amounts ($n_{control}$ = 16, n_{eco} = 18). This is in line with other findings that steak and chicken are perceived as the meat products with the highest and lowest environmental impact, respectively (Hartmann et al., 2022; Lazzarini et al., 2016; Michel et al., 2021). Hereby, steak's EP is overestimated, whereas chicken's EP is underestimated (Hartmann et al., 2022) and even perceived as comparable to that of various meat substitutes (Lazzarini et al., 2016; Siegrist & Hartmann, 2019).

Considering these findings, it appears that steak and chicken are perceived as "opposites" (within the meat product category) regarding various attributes. Specifically, steak may be the participants' mental prototype (i.e., "best example") of a meat product, whereas chicken is viewed as a meat product with opposing attributes. To illustrate this, consider this observation by Michel et al. (2021, p.6): "Steak is almost always perceived as more extreme than other food products. It is perceived as [one of] the most festive, healthy, masculine, expensive, tasty, natural, filling, and protein rich" foods. Studies describing the link between meat, power, and masculinity (Adams, 2018; Oleschuk et al., 2019; Rozin et al., 2012; Ruby & Heine, 2011; Sobal, 2005) also note that steak symbolizes meat in its "rawest" form as

cavemen ate it. In stark contrast to this are the consumers' associations with chicken (breast), which include freshness, leanness, blandness, femininity, and weight reduction (Kennedy et al., 2004). These opposing associations that consumers apparently have for steak and chicken (i.e., indulgence vs. restriction, masculinity vs. femininity, and richness vs. leanness) could be the reason why these two products stood out strongly from the large variety of options in the buffet, and thus appear to have been two important "choice anchors" in the participants' meal selection (Chernev et al., 2015).

In summary, it appears as though the eco group took several "shortcuts" in their environmentally friendly decision-making. First, the eco group did not choose foods based on perceived tastiness and appeal, but instead identified meat and fish as the food categories that needed to be excluded (or reduced) from their selection in order to keep their meal's EP low. Then, it is possible that the eco group applied a combination of the dichotomy and prototype heuristic. Our results indicate that they identified steak (a possible mental prototype of meat products) as the environmentally "unfriendly" meat product and thus did not select it. In contrast, it is possible that chicken was identified as the environmentally "friendly" counterpart that was deemed acceptable in their meal selection.

How approach 1 could have been improved: The eco group could have selected less animal-based foods (incl. egg, dairy).

The only animal-based products that the eco group chose significantly less of in comparison to the control group were steak and salmon. However, other meat and fish products, as well egg and dairy products (e.g., cheese, desserts), also have a high environmental impact when compared to the other buffet foods (Figure 7). Thus, these foods ideally should have also been excluded from the eco group's meal selection. This finding suggests that consumers are either unaware of the extent of the environmental impact of different animal-based products (Hartmann et al., 2022; Lazzarini et al., 2016), or that they possibly had such a focus on one specific heuristic (e.g., "skip the steak!") that it lead them to overlook other foods that are almost equally as important to dietary environmental friendliness.

Approach 2: The eco group selected more meat substitutes than the control group.

Overall, the eco group selected more meat substitute products than the control group. However, amongst these products, it was only the falafels that the eco group selected more of as compared to the control group. The eco group did not have a higher selection of novel "meat-mimicking" products (e.g., Quorn nuggets and filet, plant-based "chicken," Beyond Meat Burger). This is in line with previous findings that consumers appear to have a negative perception of many novel meat substitutes: Not only has it been shown that novel meat-

mimicking substitutes are perceived as less environmentally friendly than traditional plant-based high-protein foods like falafel and tofu (Estell et al., 2021; Lazzarini et al., 2016), they are also falsely perceived to have an equal or higher environmental impact than some meat products (Hartmann et al., 2022; Lazzarini et al., 2016; Siegrist & Hartmann, 2019).

Two closely related heuristics could explain this negative perception of novel meat-mimicking products. Firstly, humans act upon a familiarity heuristic, i.e., they prefer to choose the familiar versus the unfamiliar (Park & Lessig, 1981; Whittlesea & Williams, 2001). Many meat-mimicking products only entered the market in the past decade, which could explain why our participants preferred a traditional food like falafel instead. Secondly, consumers often use the perceived naturalness as a heuristic cue to form negative judgements about new technologies, since they lack the technological knowledge to come to a more objective evaluation (Siegrist & Hartmann, 2020). The perceived unnaturalness appears to also be a great barrier to consumer acceptance of novel meat substitutes (Hartmann & Siegrist, 2017; Hoek et al., 2011; Michel et al., 2021). This is closely related to the finding that consumers perceive meat-mimicking products as being highly processed. This has been described as potentially clashing with the image of plant-based, vegetarian options being healthy, clean, and natural (Jahn et al., 2021; Varela et al., 2022), which might have enhanced consumer's negative perception of the products.

In summary, our findings suggest that the eco group followed a potentially effective approach for composing an environmentally friendly meal. It appears as though they chose to replace meat and fish with a meat substitute. For this, however, they chose falafels far more frequently than any of the novel meat-mimicking products. Past research indicates that this could possibly be due to the negative attributes linked to novel meat substitute products: They are unfamiliar, perceived as unnatural, and perceived to have a high level of processing (in comparison to a food like falafel).

How approach 2 could have been improved: The eco group could have selected more plant-based foods.

Apart from meat substitutes, the buffet offered many plant-based, low environmental impact foods like vegetables, fruits, and starches (e.g., grain). Despite this, the eco group did not have a higher selection of these foods as compared to the control group. However, individuals excluding meat and fish from their meals can profit from a heightened intake of calorie-dense plant-based foods, such as grains, and high-protein vegetables, such as legumes.

Why did the eco group not select more plant-based foods in comparison to the control group? A lack in variety does not appear to have been responsible for this, since the buffet

included numerous plant-based options (Bucher et al., 2011). Instead, it appears that many high-protein plant-based foods are unpopular with consumers: beans, lentils, and peas are underused in the current food system (Asif et al., 2013), and not frequently consumed in Northern European countries (Henn et al., 2022). While these legumes are perceived to be healthy and tasty, consumers avoid eating them mainly because they are believed to cause digestive problems and to be difficult to prepare (Henn et al., 2022). Furthermore, it is possible that our participants' behavior illustrates Western consumers' tendency to compose meals according to a certain three-component-format: (1) starchy foods (e.g., pasta, potatoes), (2) meat or fish, and (3) vegetables (Uzhova et al., 2018; Woolhead et al., 2015). Since meal composition behavior is highly habitual, it can be hard to deviate from the usual "meal format" (Van't Riet et al., 2011). As a result, the eco group did not consider selecting an entirely plant-based meal.

Approach 3: The eco group chose foods because they were organic, regional, and seasonal.

As opposed to the control group, that the eco group did not choose foods based on perceived tastiness and visual appeal. Instead, our findings indicate that the eco group chose foods because they were regional, organic, and seasonal. Past studies showed that these attributes are associated with a food's perceived environmental friendliness (Annunziata & Mariani, 2018; Aprile et al., 2016; Bosona & Gebresenbet, 2018; Petrescu & Petrescu-Mag, 2015; Siegrist & Hartmann, 2019; Siegrist et al., 2015; Wallnoefer et al., 2021). To the best of our knowledge, this is the first study which indicates that these attributes may also act as heuristic cues for making environmentally friendly food choices.

However, to what extent did the eco group's heuristics actually improve the meals' environmental friendliness? In other words, are regional, organic, and seasonal foods really associated with environmental friendliness? There appears to be no straight-forward answer to this, since so many different variables and uncertainties are involved when investigating this question. Some studies report that, sustainability-wise, there are neither advantages nor disadvantages associated with the consumption of seasonal (Macdiarmid, 2014) and organic foods (Leifeld, 2012; Poore & Nemecek, 2018). Other studies report that regional (vs. non-regional) food consumption even has the potential to be more damaging to the environment (Avetisyan et al., 2014). The inconsistent findings of past research suggest that the organic production method, regionality, and seasonality may not be the most reliable indicators of food environmental friendliness.

Therefore, our results indicate that our eco group might have overestimated the role of organic production method, regionality, and seasonality in relation to food environmental friendliness. While these food attributes may entail some sustainability benefits (Nemecek et al., 2016), they are "only one small aspect of a sustainable diet in terms of dietary change […] and should not overshadow some of the potentially more difficult dietary behaviors to change that are likely to have greater benefits (e.g., overeating or meat consumption)" (Macdiarmid, 2014, p. 373). For example, it can be viewed as problematic that consumers mistakenly perceive the environmental friendliness of an organic meat product as higher than a non-organic, soy-based meat substitute (Siegrist & Hartmann, 2019). It is likely that this perception arises from a consumer's focus on a heuristic cue (i.e., organic vs. non-organic production method) that is far less influential on environmental impact than other food attributes (i.e., animal vs. plant origin). As another example, consuming less food correlates with consuming less EP (Table 7). Since Western individuals consume approximately 1300 kcal more per day than needed (UN Food and Agriculture Organization (FAO), 2018), simply eating less is a viable approach to reducing the EP of one's diet. While the eco group's meals did have less calories as compared to the control group, none of the participants mentioned food amount or calories during the Think Aloud task. Therefore, while consumers appear to have subconsciously selected less calories than usual to make a more environmentally friendly meal, this does not appear to be a conscious food selection approach for dietary sustainability.

The finding that consumers do not use the most effective heuristics for environmentally friendly food consumption (which potentially even overshadow comparatively more effective heuristics) supports that consumer's knowledge about the factors contributing to their food's environmental impact is low (Hartmann et al., 2021). However, the results of our regression analysis highlight the importance of this knowledge when a consumer is externally prompted to make environmentally friendly food choices.

2.4.3. Limitations

Certain limitations concerning the methodology and interpretation of the results are present. (A) Participants were asked to assemble a meal that was "environmentally friendly," but not "maximal" environmentally friendly. It is possible that this difference in phrasing could have impacted participants' performance; (B) Some participants did not consistently "think aloud" throughout the experiment. Thus, they had to be encouraged to talk via the experiment protocol. This likely could have impacted the results; (C) The reasons participants mentioned for *not* choosing certain foods were not recorded. This would give further insights into food

selection decision processes; (D) It is noteworthy that the sample appeared to be more educated than the average consumer, as half of the participants had an applied university or university degree; (E) While our interpretation focused on heuristic decision making, many other factors (e.g., hunger, attention, availability, cultural preferences, or social norms) influence food choices. Choosing foods from a buffet is a social practice (Reckwitz, 2002). Thus, our participants were not only influenced by individual cognitive factors (e.g., heuristics), but also by social norms of the practice. For example, consumers may have been aware that animal proteins have a large environmental impact. However, they may also have perceived it as the social norm to select (at least a minimum amount of) meat at a buffet, as it is a highly valued and expensive food. Hargreaves (2011, p. 83) concludes that "bringing about pro-environmental patterns of consumption, therefore, does not depend on educating or persuading individuals to make different decisions, but instead on transforming practices to make them more sustainable."

2.4.4. Implications and conclusion

Our daily meals have a great impact on the environment. Many consumers are becoming more aware of this and wish to improve their habits around meal composition. To support this, it is important to understand consumers' decision process when they are trying to make environmentally friendly food choices. Past research may have identified the food attributes consumers associate with sustainability. However, our daily food choices are highly complex: Foods are chosen in certain settings (e.g., at a cafeteria, a buffet), meals consist of multiple foods (e.g., side dishes, desserts), and foods are not always selected based on rationality, but sometimes on mental "rules of thumb." To this end, the current study is unique in that it places consumers in a "real life" food choice scenario, lets participants compose an entire meal, and requires participants to verbalize their decision-making in "in real time."

Our results suggest that the consumers' approaches to making environmentally friendly food choices are suboptimal. The eco group's main heuristic principle for composing an environmentally friendly meal—which appears to have been to choose less meat and fish, whilst choosing more meat substitutes—is likely to have improved the environmental friendliness of their meals. However, some of the finer selection mechanisms involved were less facilitating of their meal's environmental friendliness: (1) The eco group excluded mainly steak from their selection in order to reduce the environmental impact of their meal. However, since other animal-based products, like dairy and egg, are also high in EP, a reduction of these foods could have further lowered the environmental impact of their meals. (2) The eco group

did not have a higher selection of novel meat-mimicking meat alternatives (e.g., Beyond Meat), fruits, vegetables, or grains as compared to the control group. However, eating more of these foods as a substitute for animal-based products can be a viable approach to improving the environmental friendliness of one's meal. (3) The eco group used a food's production method (organic vs. non-organic), regionality, and seasonality as main selection heuristics. However, other dietary factors—such as food amount, which was never mentioned by participants as something they paid attention to during the buffet task—are more likely to ensure environmental friendliness.

A shift toward more environmentally friendly food selection behavior will likely require changes in consumers' perception and knowledge, as well as efforts from food producers and policy makers. Firstly, consumers' awareness of the environmental unfriendliness of animal products (including eggs and dairy) needs to be increased. With this, it is also important that consumers become more aware that the correlation between certain food attributes (e.g., regionality) and environmental friendliness may not be as large as expected. Hopefully, this will allow consumers' focus to shift toward more effective approaches (e.g., eating more plant-based foods, or not overeating). Secondly, consumers' openness toward "new" concepts of food and eating that focus on food sustainability needs to be increased. Specifically, it would be beneficial for consumers to gain a greater flexibility regarding their "typical meal format" (which usually includes meat and fish) by adopting a plant-based diet, which not only has benefits for the environment, but also for human health. Lastly, a greater acceptance of novel, sustainable food products would likely contribute toward more sustainable eating behaviors. This not only includes the plant-based alternative proteins presented in our buffet, but other foods, like insects, cultured meat, or microalgae. For this, it is important that food producers focus on creating delicious products in order to ensure optimal consumer acceptance. Furthermore, policy makers need to increase their promotion of sustainable consumption, for example by introducing regulations centered around food's environmental impact (e.g., taxes), or supporting research about and companies of novel alternative proteins. Despite the initial skepticism these unfamiliar products may elicit, they are likely to play an important role in enabling a more sustainable protein supply in the future.

Heuristics can be useful tools for navigating through life, as they can help us make fast yet reasonable decisions. However, when consumers are trying to choose environmentally friendly foods, the heuristics they follow are not always the most effective. Thus, it is of utmost importance that consumers gain more awareness about the environmental friendliness of foods and food-related attributes.

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Chapter Appendix

Table 7. Spearman's rank correlations of variables related to the selected meal.

	1	2	3	4	5	6	7	8
1 Environmental impact (EP)		.81**	.62**	.60**	.25**	.20*	.49**	.69**
2 Calories (kcal)			.14*	.71**	.38**	.45**	.77**	.62**
3 Environmental impact per calorie (EP per kcal)				.18*	-.02	-.13*	-.10*	.38**
4 Weight (g)					.51**	.38**	.46**	.45**
5 Number of food items selected						.16*	.48**	.35**
6 Carbohydrates (g)							.34**	.24**
7 Fats (g)								.50**
8 Proteins (g)								

* $p < .05$, ** $p < .001$.

Chapter 3

Palm Oil and the RSPO Label

Palm oil and the Roundtable of Sustainable Palm Oil (RSPO) label: Are Swiss consumers aware and concerned?

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Abstract

Palm oil is commonly and increasingly used in many products, despite its association with various problematic ecological, social, and health-related issues. The international Roundtable of Sustainable Palm Oil (RSPO) label is intended to guide consumers toward more sustainable palm oil product purchases. Unfortunately, it is often the case that consumers profess concern for specific food sustainability issues, yet fail to translate this into sustainable action, for example, by avoiding foods with unsustainable ingredients, or by using eco-labels. To investigate the factors associated with this discrepancy in the case of palm oil, the current study explores Swiss consumers' (N = 1076) associations with, perceptions, and awareness of palm oil and the RSPO label through an online survey. Analyses of variance revealed that our participants had mostly negative associations with palm oil, viewed palm oil more negatively than other oils and fats, and lacked acceptance of palm oil in various products. Hereby, consumers' negative perceptions of palm oil mostly concerned sustainability aspects of the fat. Despite this, only 9% of the participants were even aware of the RSPO label. Surprisingly, a regression analysis showed that this discrepancy was also evident among sustainability-concerned consumers. These results indicate that consumers' awareness and knowledge of (unsustainable) ingredients in products and corresponding eco-labels need improvement. To address this, targeted awareness and knowledge-raising interventions, as well as effective marketing could be used. Furthermore, a greater pressure on certification organizations needs to be placed, demanding a stricter adherence and transparency regarding their sustainability standards.

3.1. Introduction

Palm oil is the most widely produced, consumed, and traded vegetable oil in the world (Statista, 2021), as it has many beneficial qualities. Due to palm oil's versatility, it is an ingredient in every fifth product on the Swiss market (Bundesamt für Umwelt, 2015), most commonly in edible products (e.g., chocolate, margarine) and in non-edible products (e.g., soaps, washing detergents, cosmetics). First, it has natural preservative effects, and thus can help extend the shelf life of products (Inanç & Maskan, 2012). Second, it can be inexpensive and sustainable in comparison to other vegetable oils (e.g., soy, coconut, rapeseed, or sunflower), as it is the most efficient oilseed crop in terms of land footprint (Basiron & Weng, 2004; Corley & Tinker, 2008; Gunstone, 2011; Schmidt, 2015) and energy input (e.g., for fertilizing or milling) (Wood & Corley, 1991). For example, the production of soybean oil takes up to eight times as much land and four times as much input energy as the production of the same amount of palm oil (Organization for Economic Co-operation and Development and the Food and Agriculture Organization of the United Nations (OECD-FAO), 2016); Wood & Corley, 1991). Therefore, the production of palm oil can entail less greenhouse gas emissions, deforestation, and biodiversity loss, as well as higher yields compared to the production of other vegetable oils (Basiron & Weng, 2004; Corley & Tinker, 2008; Gunstone, 2011; Schmidt, 2015; Wood & Corley, 1991). As a result of these benefits, the demand for palm oil, which has increased eightfold in the past decades, is expected to grow (OECD-FAO, 2016).

Despite palm oil's importance in the world market, it is associated with various negative ecological, social, and health-related issues. First, even though palm oil plantations need less space and energy compared to other oilseed crop plantations, they cause a high degree of environmental degradation (e.g., deforestation, loss of biodiversity) (Butler & Laurance, 2009; Reijnders & Huijbregts, 2008; Wilcove & Koh, 2010). Second, the palm oil industry has a negative reputation regarding exploitative and inhumane plantation labor conditions, as well as the "land grabbing" and eviction of locals from their traditional lands (Carrere, 2001; Obidzinski et al., 2012). Finally, palm oil has a high concentration of saturated fat as compared to most other vegetable oils, and its consumption is associated with high blood cholesterol levels and an increased risk of cardiovascular disease (Sacks et al., 2017; Sun et al., 2015).

In recent years, these detriments have become central to the public's perception of palm oil. Specifically, multiple studies show that many consumers view palm oil very negatively—especially in terms of its associated environmental issues—and want to reduce their intake of

it (Aguiar et al., 2018; Disdier et al., 2013; Guadalupe et al., 2019; Reardon et al., 2019; Sodano et al., 2018; Verneau et al., 2019).

However, addressing consumers' concerns by banning palm oil could be problematic in several ways (Ostfeld et al., 2019). First, the livelihoods of millions of people—many of whom are from developing countries—could be endangered by an abrupt palm oil ban (European Sustainable Palm Oil (ESPO), 2017). Second, alternative vegetable oils are not only less versatile but also more expensive and less sustainable than palm oil, at least in terms of land and energy use (Basiron & Weng, 2004; Corley & Tinker, 2008; Gunstone, 2011; Schmidt, 2015). In turn, a shift away from palm oil production in favor of alternative crop seed production could entail: (A) lower yields, which potentially pose a food security and poverty threat, and (B) the need for more agricultural land, which could cause more damage to the environment (ESPO, 2017).

Therefore, a more viable approach to addressing palm oil production-associated problems could be to strive for improved palm oil production standards, for which ecological and social damage is held at a minimum as much as possible. With this goal in mind, various stakeholders from throughout the palm oil supply chain, investors, and non-governmental organizations established the RSPO in 2004. This international non-profit organization introduced a certification scheme that aims to signal that a product contains legal, economically viable, environmentally friendly, and socially beneficial palm oil. These standards are set and reviewed every five years by the RSPO General Assembly, which consists of 850 representatives of the global palm oil and food industry. Palm oil producers are certified through strict verification against these standards by accredited certification bodies. Since the RSPO is the largest palm oil certification scheme, its standards are more specific to palm oil production than those of organizations such as the Rainforest Alliance, which, for example, has a broader scope concerning general agriculture topics.

Although there is extensive literature documenting consumers' palm oil concerns (Aguiar et al., 2018; Disdier et al., 2013; Guadalupe et al., 2019; Reardon et al., 2019; Sodano et al., 2018; Verneau et al., 2019), only a few studies so far have also investigated consumers' perspectives on palm oil-related labels, such as the RSPO label. These studies show that consumers claim to be interested in a food label that addresses the problems of palm oil (Borrello et al., 2019; Riganelli & Marchini, 2017) and have a medium (Capecchi et al., 2019; Disdier et al., 2013; Hartmann et al., 2018; Reardon et al., 2019) to high (Bateman et al., 2010) willingness to pay for such labeled products. Furthermore, past research indicates that the recognition of the RSPO label appears to be very low (Ostfeld et al., 2019), at least in

comparison to other eco-labels, such as the highly recognized Swiss organic label BioSuisse (introduced in 1981) (Stolz et al., 2013), or the international UTZ label (introduced in 2002) (Delmas & Clements, 2017), which promises sustainably farmed coffee and cacao products. Piecing together findings from past research gives a general picture on how these topics—consumers' perceptions of palm oil, the RSPO label, and other eco-labels (as reference point)—intersect. With the current study, we wish to combine all these topics in order to reveal the interactions between them and thus understand the broader context.

Thus, this study aims to explore consumers' associations with, perceptions, and awareness of palm oil and the RSPO label. Specifically, we assessed consumers' associations with palm oil, compared the perceptions of palm oil vs. other fats/oils (butter, canola oil, coconut fat), assessed the perceptions of palm oil in various edible and non-edible products, and assessed awareness of the RSPO label in comparison to other eco-labels (UTZ and the BioSuisse label). To embed our findings into a broader context, we also discuss our results concerning palm oil and the RSPO label in relation to consumer behavior regarding eco-labels in general.

3.2. Methods

3.2.1. Participants

Data were collected in 2019 through an online survey in the German- and French-speaking part of Switzerland. Participants were recruited through the web-based panel of Respondi Aktiengesellschaft (AG) and received a small amount of compensation for their participation. Quotas were set on gender (50% female) and age (age range 20–70), with the same number of participants in each age category.

The sample characteristics of the included 1076 participants are displayed in Table 8. About half of the sample (57%) came from the German-speaking part of Switzerland. The participants were 51% female, with a mean age of 47 years. Educational level was measured and grouped into three categories: low (primary and secondary school or no education), coded as 1; medium (vocational school or high school), coded as 2; and high (applied university or university), coded as 3. The average educational level was medium to high (applied university or university).

Table 8. Characteristics of the study sample (N = 1076).

	Possible range	Mean or %	*SD*	item no.	Alpha[a]
Sociodemographic variables					
Age	20–70	46.53	14.25	1	
Women (%)		51.20		1	
Education				1	
Low (%)		8.80			
Middle (%)		55.80			
High (%)		35.40			
Concern about food related issues					
Sustainability concern	1–7	5.93	1.07	14	.94
Health concern	1–7	5.31	1.17	4	.86
Information-seeking on food packaging					
Sustainability information-seeking	1–5	2.99	0.80	5	.85
Health information-seeking	1–5	2.98	1.06	5	.81
Variables related to palm oil					
Affect of the associations with palm oil[1]	1–11	3.38	2.56	1	
Perception of palm oil as:					
Unhealthy vs. healthy	1–7	2.70	1.67	1	
Unsustainable vs. sustainable	1–7	4.75	2.22	1	
Low quality vs. high quality	1–7	3.05	1.71	1	
Not tasty vs. tasty	1–7	5.62	1.73	1	
Unfamiliar vs. familiar	1–7	3.58	1.86	1	
Expensive vs. inexpensive	1–7	4.96	1.77	1	
Ordinary vs. exquisite	1–7	5.09	1.73	1	
Foreign vs. domestic	1–7	1.78	1.34	1	
Awareness about palm oil in products (%)[2]	1–20	51.47		20	
Acceptance of palm oil in products (%)[3]	1–20	13.70		20	
Variables related to the RSPO label					
Awareness about the RSPO label (%)[4]	1–2	9.40		1	

Note. [a]Cronbach's Alpha. [1]How positively participants rated the affect of their association with palm oil (see Table 9). [2]Percentage of products for which participants correctly indicated palm oil as an ingredient. [3]Percentage of products for which participants deemed palm oil an acceptable ingredient. [4]Percentage of participants who reported to have seen the RSPO label before.

3.2.2. Survey questions

The questionnaire was developed in German and was also translated into French by a professional agency.

Concern about Food-related Issues.

Concern about sustainability-related food issues (abbrev. "sustainability concern") was measured with 14 items (Grunert et al., 2014). Participants were asked, "How concerned are you with the following issues?" An example item was "Deforestation of the rainforest." Responses were given on a 7-point scale ranging from "only slightly concerned" (1) to "extremely concerned" (7).

Concern about health-related food issues (abbrev. "health concern") was measured with four items taken from the general health interest subscale (Roininen et al., 1999). Participants were presented with four statements, such as, "It is important to me to have a healthy diet," and were asked to indicate their level of agreement with each statement on a 7-point scale from "I disagree strongly" (1) to "I agree strongly" (7).

Information seeking on food packaging.

Two subscales of the information seeking on food packaging scale (Grunert et al., 2014) were used. Participants were asked, "When buying food and drink products, how often do you look for the following information on food packaging?" To measure sustainability information seeking, the five answer options were as follows: 1) ingredient list, 2) country of origin, 3) organic status, 4) environmental labels (e.g., Rainforest Alliance), and 5) environmental impact (e.g., through transportation of the product). To measure health information seeking, the four answer options were as follows: 1) ingredient list, 2) nutrition facts label, 3) nutritional characteristics (e.g., low-fat, protein-rich), and 4) impact on health (e.g., impact on cholesterol levels or the bones). Responses for both subscales were given on a 5-point scale ranging from "Never" (1) to "Always" (5).

Palm oil and the RSPO label.

The associations with palm oil were assessed by asking participants the question, "When you think of palm oil, what is the first association (word, image, or thought) that comes to mind?" They were asked to name two such associations. Participants were then asked to rate each association on an 11-point scale from "Extremely negative" (1) to "Extremely positive" (11).

The *perception of palm oil* in a semantic differential format was assessed by asking participants to rate palm oil and three other fats (butter, canola oil, and coconut fat), each with regard to eight adjective pairs. These fats were chosen for the following reasons: In comparison

to palm oil, coconut fat oil is a similarly foreign fat, whereas canola and butter are fats produced in Switzerland, with the first two being plant-based and the latter being animal-based. Responses were given on a 7-point scale for the following adjective pairs: unhealthy (1) vs. healthy (7), unsustainable (1) vs. sustainable (7), low quality (1) vs. high quality (7), not tasty (1) vs. tasty (7), unfamiliar (1) vs. familiar (7), expensive (1) vs. inexpensive (7), ordinary (1) vs. exquisite (7), and foreign (1) vs. domestic (7). These adjectives were chosen because we perceived them to be the most relevant characteristics of consumers' perceptions of palm oil.

Awareness of palm oil in products was measured by presenting participants pictures of 20 edible and non-edible products currently available in Swiss supermarkets that either contain or do not contain palm oil. For each product, participants indicated if they expected palm oil in the product with the responses "Yes," "No," or "I don't know." If a participant gave the correct "Yes" or "No" answer for a specific product, this was counted as them having the correct awareness of palm oil in this product.

Acceptance of palm oil in products was measured by presenting participants with the same list of 20 edible and non-edible products. For each product, participants indicated whether they perceived palm oil in the product to be acceptable with the responses "Not acceptable," "Acceptable," or "I don't know." If a participant answered "Acceptable" for a specific product, this was counted as having an acceptance of palm oil in this product.

Awareness about the RSPO label was measured with the item "Have you ever seen this label before?" with the response options "Yes," "No," or "I don't know." If a participant answered "Yes," this was counted as them having an awareness of the label. Participants were asked this same item for the eco-labels BioSuisse (a Swiss organic label for a wide variety of products) and UTZ (an international label for coffee, cocoa, and tea signaling sustainable farming), which was used to compare consumer perceptions of the RSPO label with two well-established eco-labels in Switzerland.

3.2.3. Data analysis

All analyses were performed using the SPSS statistics software package version 26 (SPSS Inc., Chicago, IL). In the online survey, consumers had indicated their associations with palm oil in an open-ended question. These answers were coded and categorized manually, and frequencies were assessed. A significance level of alpha = .05 was used in the present study. Pearson correlations were calculated between all study variables. The rating of the fats regarding the eight adjective pairs occurred in a between-subject design to reduce the number of items shown to the participants. Thus, between-subject Analyses of Variance (ANOVA)

were conducted to assess how the perceptions of fats differed regarding the eight adjective pairs. Finally, regression analyses were conducted to predict the *(positive) affect of association with palm oil* (Model 1) and the *awareness about palm oil in products* (Model 2), both with the following predictors: age, gender, education, sustainability concern, health concern, sustainability information seeking, health information seeking, and (only for Model 2) affect of the association with palm oil.

3.3. Results

3.3.1. Associations with palm oil

The associations elicited by the term "palm oil" could be classified into 14 categories according to their meaning (Table 9). Forty-one percent of all the named associations fell into the category "negative environmental impact." In comparison, social and health-related detriments of palm oil were mentioned less frequently. Unsurprisingly, only very few participants named positive associations, which fell into the categories "healthy" and "positive evaluations." The mean affect of the association ($M = 3.21$, $SD = 2.52$) was significantly lower than the midpoint of the affect-rating scale ($t(1075) = 33.53$, $p < .001$). Thus, the mean affect of all associations with palm oil was rather negative.

3.3.2. Perception of palm oil in relation to other fats

The ratings for palm oil, butter, canola oil, and coconut fat for the eight adjective pairs are displayed in Figure 12. The exact values of the mean ratings and the ANOVA results can be found in the Chapter Appendix (Table 13). As can be seen in Figure 12, the results of the ANOVA indicate that there were statistically significant differences between the ratings for every adjective pair. Regarding pairwise differences, none of the 95% CIs of the palm oil means overlapped with those of the other fats. Thus, the participants' ratings of palm oil differed significantly from their ratings of the other fats for each adjective pair. Specifically, palm oil always received the highest or the lowest rating for each adjective pair in comparison to the other fats; palm oil was perceived as the least healthy, the least sustainable, the lowest in quality, the least tasty, the least familiar, the least expensive, the least exquisite, and the most foreign of all the fats.

Canola oil and butter were rated similarly by participants for most adjectives; for the adjectives "sustainable" and "tasty," participants gave these two fats the same rating, and for

all other adjectives, participants' ratings differed only by 0.5 at most (on a rating scale of 1–7). Coconut fat was rated similarly to palm oil regarding its unfamiliarity and foreignness.

Table 9. Associations with palm oil and their affect.

				Affect of association	
Association category	Association example	Frequen.	%	M	SD
1. Negative environmental impact	Deforestation, pollution	439	40.80	3.38	2.56
2. Unspecific negative evaluation	Bad, awful	159	14.78	2.65	2.07
3. Edible product	Nutella, chocolate	92	8.55	3.07	2.34
4. Nature	Orangutan, palm tree	93	8.64	3.55	2.80
5. Unhealthy	Unhealthy, poisonous	86	7.99	2.86	1.93
6. Vegetable oils or fats	Oil, fat, cold-pressed	45	4.18	5.68	2.96
7. Cultivation	Monoculture, plantation	36	3.35	3.00	1.95
8. No association	Don't know, nothing	36	3.35	---	---
9. Geographic location	Tropics, Asia	16	1.49	5.31	3.07
10. Unspecific positive evaluation	Good, good quality	15	1.39	8.07	2.46
11. Trade	Inexpensive, cheap	14	1.3	4.93	1.94
12. Topic relevancy	Negative media image, WWF	14	1.3	5.14	1.91
13. Healthy	Healthy, healthy fat	8	0.74	7.75	2.65
14. Other	Cosmetics, exploitation, beach, fuel	18	1.67	---	---
Sum or mean		1076		3.21	2.52

Note. The absolute frequency and the frequency in relation to the other category groups (in percentage) is given. The affect was measured on an 11-point scale from "Extremely negative" (1) to "Extremely positive" (11). No affect for "No association" and "Other" was shown, as the associations within these categories were too heterogeneous.

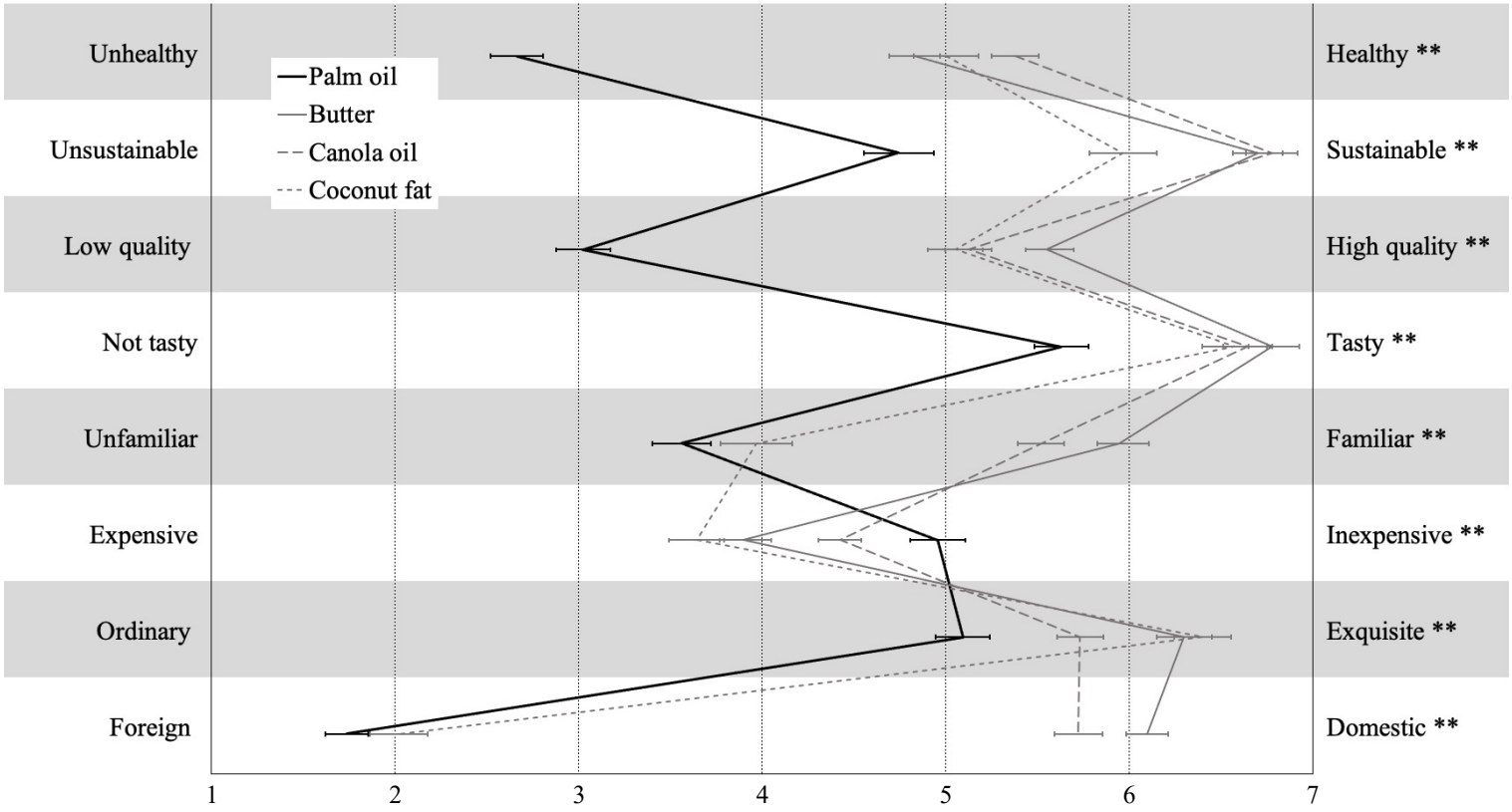

Figure 12. Participants' evaluation of different fats in respect to eight adjective-pairs. Means and 95% CIs for each mean rating are shown. Non-overlapping CIs between means indicate significant pairwise differences. ** indicate significant overall mean differences at $p < .001$ (as shown in the Chapter Appendix in Table 13).

3.3.3. Awareness and acceptance of palm oil in products

Table 10 shows the participants' awareness and acceptance of palm oil in various products. Participants were more aware of palm oil in edible products than in non-edible products. However, the reverse was true when it came to the acceptance of palm oil. Participants were more accepting of palm oil in non-edible products than in edible products. Overall (i.e., across all products), the awareness of palm oil as an ingredient was greater than the acceptance of it as an ingredient.

Regarding edible palm oil-containing products, Nutella was the product that most participants were aware of and accepting of palm oil as an ingredient. Regarding the non-edible palm oil-containing products, cream and candles were the products for which most participants were aware of palm oil as an ingredient.

3.3.4. Variables related to the RSPO label

Participants were shown the three labels (RSPO, UTZ, and BioSuisse) and were asked to indicate if they had ever seen them before (Figure 13). Only 9% (N = 105) of the participants knew the RSPO label. In contrast, 64% (N = 695) and 93% (N = 1021) of the participants recognized the UTZ and BioSuisse labels, respectively.

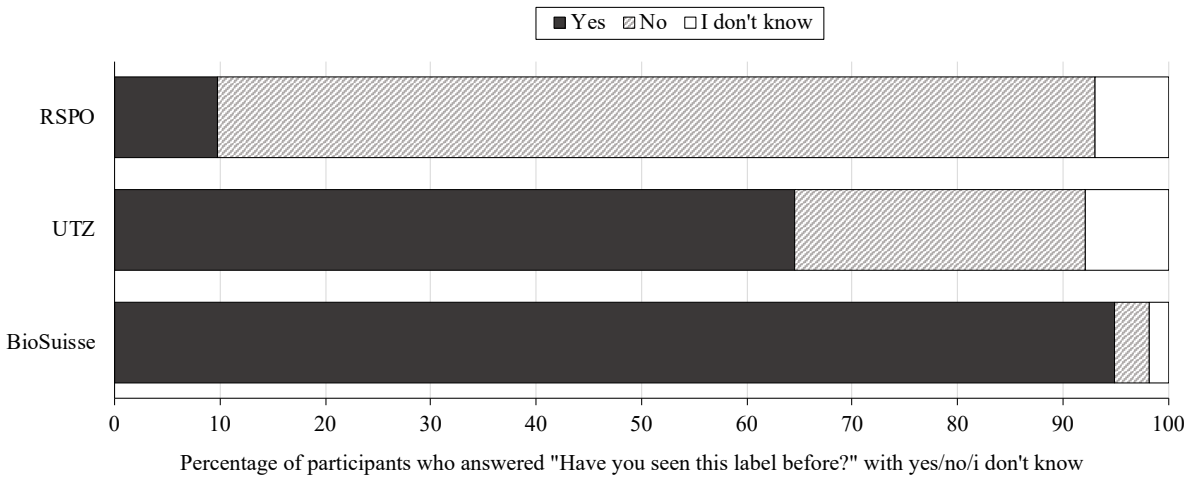

Figure 13. The awareness of the different labels.

Table 10. The awareness and acceptance of palm oil in various products.

	Awareness of palm oil	Acceptance of palm oil
	% of participants who were correctly aware that palm oil is or is not an ingredient	% of participants who perceived palm oil as an acceptable ingredient
Edible products		
Spaghetti	91.80	6.70
Nutella[+]	90.60	21.70
Wiener sausages	84.10	6.70
Ready-made "Spätzli"	68.50	9.90
Dark chocolate	67.10	10.80
Margarine[+]	58.60	18.60
Paprika chips	58.20	13.80
Ice cream	54.30	10.30
Pastries "Spinatplätzli"[+]	52.10	13.20
Cookies[+]	47.90	11.50
Ready-made cookie dough	44.00	11.40
Chocolate with Nougat filling	42.30	14.40
Baby food spelt biscuits[+]	27.60	7.20
Vegetable bouillon[+]	24.20	13.60
Muesli cereals[+]	22.70	6.70
Non-edible products		
Cream[+]	53.30	16.90
Candles[+]	52.00	25.70
Shower gel[+]	45.00	15.70
Biodiesel fuel[+]	29.60	19.90
Washing detergent[+]	15.50	13.70

Note. [+]Indicates that the product typically contains palm oil.

3.3.5. Consumer characteristics associated with palm oil and RSPO label variables

One interesting finding in Table 11, which shows the correlations between the study variables, was that high concern for sustainability, negative affect, and low acceptance of palm oil in products did not correlate significantly with the awareness about palm oil in products and the RSPO label. This is surprising because one would expect consumers who care about the environment and who are critical of palm oil to be more aware of which products contain palm oil, as well as a sustainable palm oil label like that of the RSPO.

To investigate this association further, two linear regressions were conducted (Table 12). In the first regression model, the dependent variable *(positive) affect of the association with palm oil* corresponded to how positively participants rated the affect of their association on a scale from "Extremely negative" (1) to "Extremely positive" (11). The variance of this variable was explained by 30% (R^2 = .30), $F(7, 1063) = 14.718$, $p < .001$. In the second regression model, the dependent variable was *awareness about palm oil in products;* participants were asked to indicate for 20 products whether they did or did not contain palm oil—the variable indicated how many correct answers participants gave across all the products, on a scale from 1 (no correct answers) to 21 (all answers correct). The variance of this variable was explained by 17% (R^2 = .17), $F(8, 1062) = 3.874$, $p < .001$. Participants who had a more positive affect toward their association with palm oil were male (β = -.09, p = .004), had a lower education (β = -.08, p = .005), and were less concerned about food-related sustainability (β = -.26, $p < .001$) than participants who had a more negative affect toward their association with palm oil. Interestingly, while participants who sought out health information on food packaging were more likely to have a positive affect toward palm oil (β = .14, p = .005), participants who sought out sustainability information on food packaging were more likely to have a negative affect toward their association with palm oil (β = -.11, p = .036). Participants who had a greater awareness of palm oil in products had higher education (β = .08, p = .04).

Table 11. Inter-correlations among study variables.

	1	2	3	4	5	6	7	8	9	10	11
1 Age		-.03	-.14**	-.04	.13**	.24**	.16**	-.07	-.02	-.07	.10*
2 Gender (0 = m, 1 = f)			-.12**	-.14**	.09*	.11**	.12**	-.11**	-.03	-.05	-.03
3 Education				.31**	.01	.01	.03	-.05	.09*	.02	.04
4 Sustainability concern					.47**	.46**	.35**	-.26**	.02	-.26**	.02
5 Health concern						.49**	.46**	-.10*	.08	-.18**	.08
6 Sustainability information-seeking							.81**	-.10*	.05	-.23**	.05
7 Health information-seeking								-.05	.05	-.18**	.05
8 (Positive) affect of the association with palm oil									-.04	.42**	.07
9 Awareness about palm oil in products										.01	.04
10 Acceptance of palm oil in products											.06
11 Awareness about the RSPO label											

Note. * $p < .05$. ** $p < .001$.

Table 12. Regression analyses predicting the affect of the association with palm oil, and the awareness about palm oil in products.

	(positive) Affect of association with palm oil[1]			Awareness about palm oil in products[2]		
	B	95% CI	β	*B*	95% CI	β
Constant	8.01	[6.89, 9.12]		10.57	[8.92, 12.21]	
Age	< 0.00	[-0.01, 0.01]	-0.01	-0.01	[-0.02, 0.01]	-0.02
Gender (0 = m, 1 = f)	-0.44	[-0.74, -0.13]	-0.09**	-0.24	[-0.65, 0.17]	-0.04
Education	-0.12	[-0.20, -0.03]	-0.08*	0.14	[0.03, 0.26]	0.08*
Sustainability concern	-0.63	[-0.79, -0.46]	-0.26**	-0.07	[-0.30, 0.17]	-0.02
Health concern	0.04	[-0.11, 0.19]	0.02	0.20	[-0.01, 0.41]	0.07
Sustainability info. seeking	-0.36	[-0.69, -0.02]	-0.11*	0.10	[-0.36, 0.55]	0.02
Health info. seeking	0.41	[0.12, 0.69]	0.14*	0.02	[-0.37, 0.41]	0.01
Affect of association with palm oil				-0.05	[-0.13, 0.03]	-0.04

Note. [1]How positively participants rated the affect of their association with palm oil [2]Degree to which participants knew that palm oil is in the products displayed in Table 10. * $p < .05$, ** $p < .001$.

3.4. Discussion

In summary, our results demonstrate that although consumers have concerns about and low acceptance of palm oil, they have insufficient awareness about which products contain palm oil and about the RSPO label. Surprisingly, this was also observable for consumers who were highly critical of palm oil, as well as those with high sustainability concerns and sustainability information seeking.

3.4.1. Consumers are highly critical of palm oil

Associations with palm oil.

Our results confirm that consumers are indeed highly critical of palm oil (Aguiar et al., 2018; Disdier et al., 2013; Guadalupe et al., 2019; Reardon et al., 2019; Sodano et al., 2018; Verneau et al., 2019) since most consumers' associations with palm oil were negative. The associations revealed the detriments of palm oil that were most relevant to participants.

Environmental detriments of palm oil (e.g., deforestation, forest fires) were by far the most frequently elicited type of association, followed by health detriments. There were only a few social and ethical associations, confirming consumers' preoccupation with environmental and health-related issues in comparison to the social issues of palm oil (Reardon et al., 2019; Sodano et al., 2018).

The regression analysis confirmed past findings that particularly sustainability-oriented consumers are critical of palm oil (Borrello et al., 2019; Ostfeld et al., 2019). First, while high sustainability concerns predicted a negative affect toward palm oil associations (hereby being the strongest predictor of the model), health concerns did not. Second, while high sustainability information seeking predicted a negative affect toward palm oil associations, health information seeking did not. Thus—although palm oil is associated with both sustainability- and health-related detriments and one would therefore expect that it would be viewed equally critically by both sustainability- and health-oriented consumers—it appears that mainly sustainability-oriented consumers, more so than health-oriented consumers, are concerned with palm oil.

Perception of palm oil compared to other fats and products.

When comparing participants' perceptions of palm oil to those of butter, canola oil, and coconut oil, we found that palm oil is viewed as inferior in comparison to these other fats. Specifically, we found that palm oil received the most "negative" rating for most adjective pairs, being rated the least healthy, the least sustainable, the lowest in quality, the least tasty, and the least exquisite. These results are in line with those of Guadalupe et al. (2019) and Ostfeld et al. (2019), who also compared the perception of palm oil to other fats/oils. This shows that participants have a negative perception of palm oil on a holistic, general level. It is possible that our participants' negative associations with palm oil—which were mostly related to sustainability- and health-related detriments—influenced their overall judgment of palm oil, an effect referred to as the negative halo effect (Nisbett & Wilson, 1977). Specifically, our participants' impressions of palm oil being unsustainable and unhealthy could have "tainted" their perception of palm oil regarding unrelated traits (i.e., they also perceived palm oil to be the least qualitative, the least tasty, and the least exquisite oil). Second, in accordance with Ostfeld et al. (2019), we found that consumers inaccurately perceive palm oil to be less sustainable than other oils, even though palm oil is one of the most sustainable and inexpensive oils in terms of land, energy, and yield efficiency (Basiron & Weng, 2004; Corley & Tinker, 2008; Gunstone, 2011; Schmidt, 2015; Wood & Corley, 1991). Interestingly, participants rated

butter, which has a significantly higher environmental impact than most plant-based fats (Liao et al., 2020), as the most environmentally friendly fat (together with canola oil).

Palm oil in different products.

Notably, our Swiss participants were by far the most aware and accepting of palm oil in one particular product—Nutella—the notorious media "poster child" of palm oil products (Cova & D'Antone, 2014; Pace et al., 2016). This sweet hazelnut spread could have acted as a cognitive prototype (Rosch & Lloyd, 1978) for foods containing palm oil, as participants were more aware of palm oil in chocolate and sweet bakery goods (i.e., products highly associated with Nutella) than in savory products (e.g., vegetable stock). This perception was also found in a Spanish and Peruvian sample (Guadalupe et al., 2019), indicating that consumers all over the world have a low awareness of the extent to which palm oil is part of their daily diets. While consumers are aware of the presence of palm oil in sweet snacks and desserts (Hartmann et al., 2018), consumers are less aware that it is also in savory foods. Regarding non-edible products, palm oil was less accepted in products to be put in direct physical contact with the skin (e.g., shower gel, cream, washing detergent) vs. non-direct physical contact (e.g., candles, fuel). It is possible that consumers' low acceptance of and highly negative affect toward palm oil made them subconsciously view palm oil as a "harmful substance" with which they would rather not come into direct physical contact. Across all products, the awareness and acceptance of palm oil as an ingredient was low. Reardon et al. (2019) confirmed this and showed that UK and Singaporean participants were less aware than Malaysian participants of palm oil in everyday products. Seeing that Malaysia is the second-largest palm oil producer in the world, it makes sense that citizens of this country would have a greater awareness of which products contain palm oil compared to citizens of countries like the UK, or in our case, Switzerland (where no palm oil is produced).

3.4.2. Consumers are unaware of palm oil in products and the RSPO label

Considering the results of the first part of this study—which suggest that consumers are highly skeptical of palm oil, especially in terms of its environmental detriments—the following two findings were surprising.

First, even though consumers with high sustainability concerns and sustainability information-seeking behavior had the most negative associations toward palm oil, they were not more likely to have a heightened awareness about palm oil in products in comparison to "average" consumers (i.e., consumers with lower sustainability concerns and sustainability information seeking). As a result, it is unlikely that this segment can translate their pronounced

palm oil concerns into more sustainable palm oil product choices, as they are not even aware of which products contain palm oil.

Second, even though all participants viewed palm oil negatively concerning various aspects, only 9% of them were aware of the RSPO label. In contrast, 64% and 93% of the participants were aware of the UTZ and BioSuisse labels, respectively. Ostfeld et al. (2019) reported similar findings in a UK sample. Specifically, they found that the recognition rate of the RSPO label (5%) was the same as that of the fictitious label invented for the study. Therefore, they concluded that the "recognition of the RSPO label (was) essentially zero in the sense that its recognition was indistinguishable from the fictitious eco-label" (Ostfeld et al., 2019, p. 5). In contrast, the majority of participants in that study (82%) recognized more established labels, such as the *Fairtrade* eco-label.

3.4.3. The concern–behavior gap regarding the use of eco-labels

Consumers are highly critical of palm oil. However, they don't know which products contain palm oil, nor do they know of the RSPO label. This discrepancy may be connected to the *concern–behavior gap* in the case of food labels (Dunlap & Jones, 2002), the phenomenon that many consumers report substantial concern for specific food issues (Van Loo et al., 2015, 2014) but do not show this in their actions by purchasing labeled products (Grunert et al., 2014; Horne, 2009; Pedersen & Neergaard, 2006). For example, Grunert et al. (2014) found that their participants claimed to care quite highly about food sustainability but at the same time reported to hardly ever use eco-labels (they were asked about the Fairtrade, Rainforest Alliance, Carbon Footprint, and Animal Welfare labels) for their food purchases. Grunert et al. (2014) suggested that this gap between concern and purchase behavior was most likely influenced by the fact that their participants had a low understanding of what the labels meant. Similarly, we argue that if consumers don't know which products contain (unsustainable) ingredients (e.g., palm oil) and do not recognize the eco-labels (e.g., the RSPO label), then it is unlikely that they will be able to make more sustainable purchases.

3.4.4. Limitations

All self-reported instruments, such as surveys, are susceptible to socially desirable responding—i.e., the tendency to give answers that make the respondent look good (Martin & Nagao, 1989). Since this has been shown to be especially relevant for research topics on pro-environmental attitudes and behavior (Milfont, 2009), this issue is likely relevant for the current study.

The nationality of consumers has been shown to impact their perception of palm oil and palm oil-related labels (Guadalupe et al., 2019; Reardon et al., 2019). For instance, consumers of industrialized and Western countries seem to be less aware of, but more willing to pay for, free-from or sustainable palm oil products compared to Malaysian consumers (Reardon et al., 2019). Our results therefore have limited generalizability, especially concerning consumers of palm oil-producing countries. Therefore, when evaluating the effectiveness of eco-labels, researchers ought to take into account country-specific differences (Zepeda et al., 2013).

The current study does not take cognitive factors into account, such as consumers' visual attention to labels on food products (Graham & Jeffery, 2012; Graham et al., 2012; Van Herpen & Van Trijp, 2011; Visschers et al., 2010). More research is needed on how these cognitive factors interact with the attitudinal and behavioral variables investigated in the current study to optimize consumers' label utilization.

The current research presents the use of the RSPO label as an approach to address the negative aspects of palm oil production and consumption. However, there are several limitations to the RSPO label in this function. First, although the health detriments of palm oil are frequently referred to throughout this paper, these are not addressed by the RSPO label. There are hardly any labels that combine environmental, ethical, and health-related aspects in one. Therefore, future research should investigate how different informational cues can be effectively represented in a single label without overwhelming consumers (Sirieix et al., 2013; Van Loo et al., 2015). Second, it is questionable to what extent the RSPO and its actors can uphold their standards of sustainability (Laurance et al., 2010). For example, although RSPO-certified plantations, in comparison to non-certified plantations, have lower greenhouse gas emissions (Schmidt & De Rosa, 2020), less forest-fire activity, and less deforestation (Cattau et al., 2016), they negatively impact orangutan populations (Morgans et al., 2018). Regarding the RSPO's sociopolitical goals, Pye (2019) argues that certification represents merely a "technical fix which neglects underlying dynamics of power, class, gender, and accumulation" (Pye, 2019, p. 219); its impact on ensuring fair land rights, worker's rights, and the reduction of poverty is therefore limited. As the last example, the RSPO has been criticized for granting certification to large-scale plantations but not to smallholder plantations, even though the latter contribute to 40% of the current palm oil production (Azhar et al., 2017). It should be noted that shortcomings regarding standard monitoring are allegedly a prevailing problem for most eco-labeling schemes (Herrup, 1999; Van Amstel, Driessen & Glasbergen, 2008). In conclusion, a shift toward more sustainable palm oil-based consumption not only requires a change in consumer behavior but also improvements from the RSPO concerning stricter

monitoring, enhanced transparency, goal setting, and membership granting (Godar et al., 2015).

3.4.5. Implications

Palm oil is associated with environmental, social, and health-related detriments. However, banning palm oil would be problematic because it sustains the livelihood of millions of people and can be cheaper and more sustainable than alternative vegetable oils. Therefore, it is important that the sustainability of palm oil production is improved and ensured—a goal that the RSPO seeks to address. However, even though the public appears highly critical of palm oil, they are not aware of the presence of palm oil in many products, nor do they know about the RSPO label. Without this knowledge, it is unlikely that consumers can consciously improve their sustainable palm oil-based purchases. Surprisingly, even the highly sustainability-concerned consumers—the ones we found to be most critical of palm oil—lacked awareness of palm oil in products and failed to recognize the RSPO label. These findings may be connected to a problem that has been limiting the success of many eco-labeling schemes: Even though consumers report substantial concern for specific food issues, this does not always translate into their use of eco-labeled products (Grunert et al., 2014; Horne, 2009; Pedersen & Neergaard, 2006). Our results suggest that the lack of awareness and knowledge regarding eco-labels may be the limiting factor hereby.

The current study highlights the importance of increasing consumers' awareness and knowledge about which products contain potentially unsustainable ingredients (e.g., palm oil) and about eco-labels associated with these ingredients (e.g., the RSPO label). Moreover, consumers should be made aware of the complexities of the topic. In the case of palm oil, for example, consumers tend to focus on the environmental damages of palm oil production but appear unaware of the oil's sustainability in comparison to other oils. As a result, some consumers are in favor of boycotting palm oil, even sustainable palm oil. Public campaigns aiming to increase consumer awareness and knowledge about palm oil and the RSPO label ought to address such widespread misconceptions and deliver unbiased, science-based messages.

Targeting information communication to a specific group can be more effective than untargeted information communication (Farahat & Bailey, 2012). Our results imply that this target group for increasing awareness and understanding of eco-labels could be sustainability-oriented consumers, since the "bridging" of their concern–behavior gap holds the most potential, seeing that "the more motivated consumers are, the more they are willing to put effort

into understanding the labels and using them" (Grunert et al., 2014, p. 178). Thus, we suggest that producers, policymakers, and public educators target this segment through their informational campaigns aimed at raising awareness and understanding of eco-labels. Hopefully, the positive behavioral change that may occur for these consumers will then be mimicked by other consumers in the form of a "contagion effect," which has been shown to contribute to the uptake of various kinds of pro-environmental behavior (Loschelder et al., 2019; Zorell, 2020).

Apart from increasing public awareness and knowledge, effective marketing can further contribute to the public's interest in buying eco-labeled products. For example, a study by Bateman et al. (2010) showed that Western consumers were willing to pay a premium price for products containing palm oil that was "tiger-friendly," whereas their willingness to pay for "sustainable" certified palm oil—which in theory also promises biodiversity conservation—is not always as pronounced (Capecchi et al., 2019; Reardon et al., 2019). This suggests that marketing strategies highlighting specific sustainability benefits may be more likely to convince consumers to buy eco-labeled products than "general" sustainability claims. Various other approaches to improving consumers' eco-label use have been discussed in past literature, such as incentivizing consumers to buy eco-labeled products through payback schemes, establishing consumer accountability frameworks, or nudging consumers through different label framings (Codagnone et al., 2016; Horne, 2009; Pedersen & Neergaard, 2006).

Maximizing sustainable consumption through eco-labels not only requires a change in consumer behavior but also efforts from certification scheme organizations and policymakers. Using the RSPO as an example, Ostfeld et al. (2019) suggested that the organization could address its criticism (Azhar et al., 2017; Laurance et al., 2010; Pye, 2019) by implementing stricter monitoring and transparency of RSPO members that are upholding sustainable standards, as well as focusing on addressing the underlying social inequalities of the palm oil industry (e.g., by granting certification to smallholder plantations). They also suggest that national policies aiming to increase companies' sourcing of certified sustainable palm oil would be beneficial. In conclusion, to ensure that consumers' eco-label purchases have a positive impact, it is important that certification organizations maintain their sustainability standards, and policymakers provide support as well.

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Chapter Appendix

Table 13. Participants' evaluation of different fats.

	Palm oil	Butter	Canola oil	Coconut fat	Omnibus Test ANOVA
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*F*(*df1*, *df2*)
Unhealthy - Healthy	2.70 (1.67)	4.83 (1.61) [a]	5.37 (1.5)	5.00 (1.56) [a]	(3, 1073) 10.973 **
Unstainable - Sustainable	4.75 (2.22)	6.68 (1.58) [a]	6.75 (1.67) [a]	5.95 (1.61)	(3, 1033) 165.507 **
Low quality - High quality	3.05 (1.71)	5.54 (1.34) [a]	5.12 (1.5) [a]	5.05 (1.31) [a]	(3, 1070) 9.771 **
Not tasty - Tasty	5.62 (1.73)	6.35 (1.81)	6.62 (1.57) [a]	6.55 (1.53) [a]	(3, 1017) 33.452 **
Unfamiliar - Familiar	3.58 (1.86)	5.93 (1.38)	5.51 (1.47)	3.98 (1.72)	(3, 1073) 135.788 **
Expensive - Inexpensive	4.96 (1.77)	3.91 (1.48)	4.43 (1.36)	3.66 (1.33)	(3, 1075) 30.016 **
Ordinary - Exquisite	5.09 (1.73)	6.28 (1.75) [a]	5.72 (1.48) [a]	6.38 (1.35)	(3, 1060) 59.129 **
Foreign - Domestic	1.78 (1.34)	6.08 (1.32) [a]	5.71 (1.54) [a]	2.06 (1.39)	(3, 1073) 709.848 **

Note. M (*SD*) are given in respect to eight adjective-pairs, as well as the omnibus ANOVA and post hoc test results.
** $p < .001$. Different (or no) letters indicate significant differences ($p < .001$) according to *Dunnett* post hoc test.

Chapter 4

Insects as Food

Correlates of the willingness to consume insects: A meta-analysis

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Abstract

Although insects are a sustainable meat alternative, the willingness to consume (WTC) them remains generally low. We synthesized the effects of WTC correlates reported in 37 studies, and also investigated the moderating effects of certain study characteristics. Across a large number of studies, affect-based factors, such as *food neophobia*, *disgust*, and *the expected unpleasant taste of insects*, were consistently strongly correlated with WTC ($\bar{r}$ = -.33–.55). Information-based factors, such as *the perceived sustainability of insects as food*, and *the perceived nutritiousness of insects as food*, also impacted WTC ($\bar{r}$ = .32–.55). However, the number of contributing studies for these factors was low. Curiosity appears to be relevant to WTC because *food sensation and innovation seeking* ($\bar{r}$ = .29) positively impacted WTC. *Age*, *education,* and *gender* were relatively unrelated to WTC ($\bar{r}$ = -.14–.00) across a large number of studies. Combatting affective barriers through gradual and/or early exposure—i.e., increasing the *familiarity with the concept of eating insects* ($\bar{r}$ = .10), and allowing consumers' experiences with *insect consumption* ($\bar{r}$ = .35) to develop over time—will help foster entomophagy acceptance in the long run. In comparison, information-based interventions may have limited effectivity, but can be implemented in the short term. As meta-regressions have shown, future researchers must consider whether the presentation of the edible insects has moderating effects, e.g., presenting actual products (β = -.56) vs. pictures of such products (β = -.55). Classical psychological entomophagy factors have been explored comprehensively, and research should also adopt a more market-oriented focus.

4.1. Introduction

The world demand for animal protein continues to increase along with a rapidly growing population. However, conventional meat production systems cannot sufficiently meet these needs, and also carry high environmental costs. Alternative, more sustainable protein sources are therefore needed (Boland et al., 2013). According to a UN report, one answer to these global concerns could be the more widespread adoption of insects into the human diet (Van Huis et al., 2013). Firstly, insects are high in protein and key macronutrients and lower in cholesterol than many other meat products (Belluco et al., 2013; Nowak et al., 2016; Payne et al., 2016). Secondly, the production of insects may have lower costs as compared to livestock production in terms of feed conversion efficiency, greenhouse gas and ammonia emissions, water and land use, and animal welfare (Halloran et al., 2016; Oonincx et al., 2010; Smetana et al., 2015). In fact, the production of insects can have a lower environmental impact than many other meat alternatives, such as cultured meat, or milk-, gluten and myco-based proteins (Smetana et al., 2015).

Although there is a growing awareness of these nutritional and environmental benefits, the willingness to consume (WTC) insects remains low for the majority of the population, especially in Western countries (Hartmann et al., 2015; Verbeke, 2015). To identify the psychological barriers responsible for this, research on the acceptance of entomophagy (e.g., the practice of eating insects) has expanded in recent years. While there have been several reviews compiling these studies qualitatively (Hartmann & Siegrist, 2017b; Kim et al., 2019; Mancini et al. 2019; Sogari et al., 2019), the current meta-analysis is one of the first attempts at a quantitative synthesis. We therefore present not only an overview of factors related to entomophagy acceptance, but also estimates of their effect sizes. This allows for an approximate quantification of the importance of various WTC correlates (both as individual factors and in comparison with one another) and certain study characteristics of past entomophagy acceptance research (in terms of moderating effects). Furthermore, we provide an overview of methodological aspects of previous entomophagy studies and identify which variables have been investigated frequently and—in turn—which variables should be given more attention. Our findings aim to consolidate the existing body of knowledge on the barriers to and potential avenues for the acceptance of edible insects and may also illuminate the next steps appropriate for entomophagy acceptance research.

4.2. Methods

4.2.1. Selection of relevant studies

A literature search of Web of Science (Core Collection) was conducted in May 2020. The Advanced Search tool was used with the following search string: TI = (insect* OR bug* OR entomophagy) AND TS = (substitute OR alternative OR sustainable OR replac* OR entomophagy OR "eating insects" OR "insects as food") AND TS = (consum* OR behav* OR accept* OR perception* OR attitude* OR eat*). The search was restricted to articles published in the English language.

The study selection process is depicted in Figure 14; the inclusion and exclusion criteria are summarized in Table 14. The literature search yielded 1023 records. In a first step, the titles and abstracts of these records were screened and 968 records that did not meet the inclusion criteria were eliminated. In a second step, the remaining 55 records were read in full, and eight more records were eliminated because they did not meet the inclusion criteria. Most of these eliminated records were excluded because they did not provide effect size(s) specifically, related to consumers' willingness to consume insects as food. For example, Barsics et al. (2017) investigated the overall liking of insects as food, not WTC. As another example, Ebenebe, Amobi, Udegbala, Ufele and Nweze (2017) was not included, because their findings were given in frequencies, not as effect sizes. The identification and screening of the records were performed independently by two parties. Interrater agreement was high (r = .90), and discrepancies between the parties were resolved by a more thorough review of the eligibility of the articles in question. Overall, 47 records met the inclusion criteria.

Because the current review aims to analyze the correlational effect between the willingness to consume insects (WTC) and various variables ("WTC correlates"), these specific correlation coefficients had to be extracted from the 47 records meeting the inclusion criteria. This occurred in two ways: In 14 records, Pearson's r correlation coefficients relevant to the current meta-analytic objective were reported. These were taken directly into the analysis. For the remaining 33 records, statistical values were not given as Pearson's r correlation coefficients, and the corresponding authors were therefore contacted to obtain the correlation coefficients. Through this method, the relevant correlation coefficients of 23 records were obtained and included in our analysis. Eight records were eliminated because the authors did not respond, and three records were eliminated because the provided data were unusable. One not-yet-published record was identified through personal communication with the author. Ultimately, 37 records were included in the review.

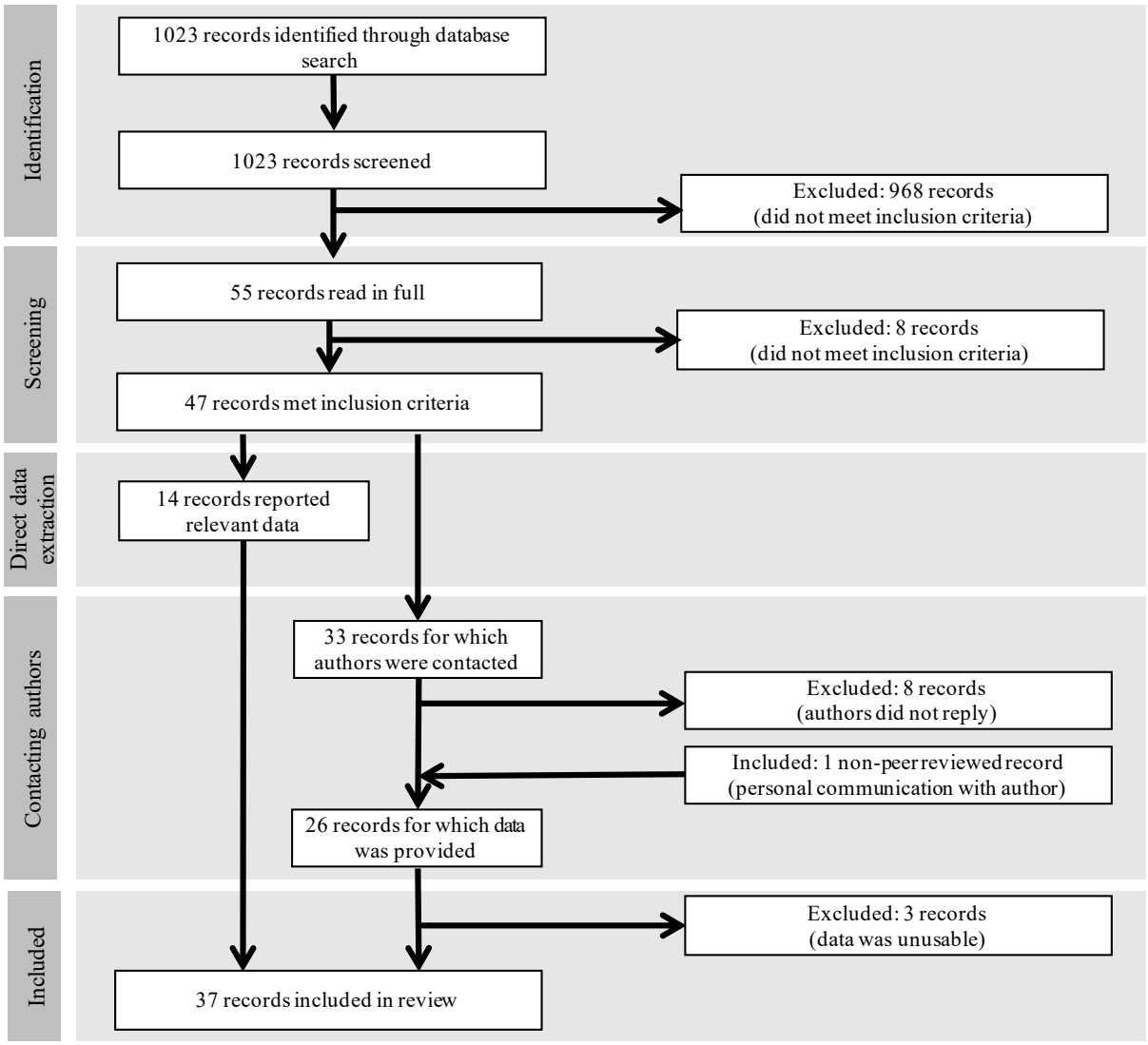

Figure 14. Summary of the selection process of the included literature.

Table 14. Inclusion and exclusion criteria used for the article selection.

Inclusion criteria
▪ Quantitative study ▪ Full-text paper in the English language ▪ Investigates consumers' willingness to consume insects as food or related measures, such as willingness to try, buy, eat, pay, purchase, or adopt insects as food ▪ Provides an effect size correlating at least one variable to consumers' willingness to consume insects
Exclusion criteria
▪ Qualitative studies, review articles, opinion papers and outlooks, conference papers and abstracts, concept articles ▪ Not related to consumer behavior (e.g., insect-based food technology development, human digestion of insect proteins, environmental impact of insect production systems) ▪ Focus on sensory perception of insects as food ▪ Focus on consumer perception of insects primarily as feed ▪ Does not provide an effect size correlating at least one variable to consumers' willingness to consume insects as food

4.2.2. Study information

Table 15 shows the general study characteristics (sample size, country of origin, and data collection method) and more detailed study information. Specifically, it shows the WTC type assessed in the studies (WTT: willingness to try insects as food; WTE: willingness to eat insects as food; WTP: willing to pay for insects as food; WTA: willingness to adopt insects as food), the presentation of the insect food (descriptions, pictures, or the real products) and the type of insect food investigated in the studies (specific insect products were mentioned such as "insect patties"; or there was no specification given concerning the food type and insects were referred to simply as "edible insects"). Additionally, brief descriptions of the insect food presented in the studies are given.

Table 15. Overview of included studies.

Study	*N*	Sample country	Data coll.	WTC measure	Insect food presentation	Insect food type	Insect food description	Measured WTC-correlate
Baker et al. (2016)	207	US	OS	WTP	P	S	insect spice-mix, insect fried-rice	23, 25
Brunner and Nuttavuthisit (2019)	942	Switzerland, Thailand	PPS	WTA	D	S	insect patties, insect chips, etc.	1, 2, 3, 5, 6, 7, 17, 20, 21, 23, 24, 27, 28, 29
Chan (2019)	202	Mechanical Turk	OS	WTT	D	S	"insects as meat substitute," deep-fried insects, insect cookies	22, 30
De Boer et al. (2013)	1083	Netherlands	OS	WTE	D	S	insect snack	1, 2, 3, 7, 9
Dupont and Fiebelkorn (2020)	187	Germany	PPS	WTE	P	S	insect patties	1, 2, 6, 7, 13, 14, 20
Dupont et al., pers. comm.	497	Germany	PPS	WTE	P	S	insect patties	1, 2, 3, 6, 7, 8, 13, 14, 19, 20, 21
Elorinne et al. (2019)	567	Finland	OS	WTE	D	NS	"foods of insect origin"	6, 8, 16, 22, 23, 24, 25, 27, 28, 29, 31, 32, 33, 34
Fischer and Steenbekkers (2018)	140	Netherlands	E	WTT	D	NS	whole insects	1, 2, 6, 22
Gere et al. (2017)	400	Hungary	OS	WTE	D	NS	"food containing insect ingredients"	6, 20, 21
Gmuer et al. (2016)	428	Switzerland	OS	WTE	P	S	insect chips, deep-fried insects	1, 2, 6, 7, 21, 22, 23, 26
Grasso et al. (2019)	1825	EU countries	OS	WTE	D	NS	"foods containing insect-based protein"	1, 2, 3, 9, 10, 11, 12, 15, 16
Hartmann and Siegrist (2016)	104	Switzerland	E	WTE	R	S	insect chips	1, 3, 6, 7, 8, 20, 22, 23, 26
Hartmann et al. (2015)	995	Germany, China	OS	WTE	P	S	"insects as meat substitute," deep-fried insects, insect cookies	1, 2, 3, 6, 9, 11, 12, 15, 17, 20, 21, 23, 24, 30
Jensen and Lieberoth (2019)	189	Denmark	OS	WTE	R	S	roasted insects, insect spring rolls, insect soup	6, 21, 22, 24
Kornher et al. (2019)	311	Germany	E	WTP	P	S	insect patties	1, 2, 3, 6, 7, 9, 10, 11, 12, 22
La Barbera et al. (2018)	160	Western countries	CAS	WTA	D	NS	"insect-based food"	6, 22, 26
Lammers et al. (2019)	516	Germany	OS	WTE	P	S	insect patties, whole insects	1, 2, 3, 4, 6, 7, 8, 13, 14, 19, 20, 21
Legendre et al. (2019)	337	US	OS	WTP	D	NS	"edible insects"	20, 23
Mancini et al. (2019)	165	Italy	PPS	WTE	R	S	"insects," insect bread	6, 24
Megido et al. (2014)	189	Belgium	PPS	WTE	R	S	flavored whole insects	1, 2, 20

Note. Table continues on next page.

Table 15. *(continued)*

Megido et al. (2016)	159	Belgium	E	WTE	R	S	insect patties	1, 20, 21, 23, 33
Menozzi et al. (2017)	213	Italy	OS	WTE	D	NS	"products containing insects"	1, 24, 27, 29, 34
Orsi et al. (2019)	293	Germany	OS	WTE	P	S	insect patties, insect protein bars, insect pasta, insect granola	1, 2, 3, 4, 5, 6, 7, 20, 21, 22, 25
Piha et al. (2018)	887	EU countries	OS	WTP	P	S	roasted insects, insect nuggets, insect snack, insect wok, insect seasoning	6, 21
Powell et al. (2019)	510	UK	E	WTP	P	S	various insect foods (e.g., insect patties)	1, 2, 3, 4, 7, 18, 23, 25, 28, 29, 30, 32, 33
Rozin and Ruby (2019)	675	US, India	OS	WTE	D	S	various whole and roasted insects (e.g., crickets)	
Ruby and Rozin (2019)	692	India, US	OS	WTE	P	S	insect tacos, insect dosas, insect lollipops, insect cookies, insect parathas	22, 25, 28
Ruby et al. (2015)	399	US, India	OS	WTT	P	S	insect tacos, insect dosas, insect lollipops, insect cookies, insect parathas	6, 8, 22, 25, 27, 30, 32
Schäufele et al. (2019)	342	Germany	CAS	WTT	P	S	insect risotto rice	1, 2, 3, 6, 7, 20, 21, 24, 31
Schösler et al. (2012)	1083	Netherlands	OS	WTT	P	S	insect pizza, chocolate-coated insects, insect salad	1, 2, 3, 7
Sogari et al. (2019)	88	Italy	PPS	WTE	D	NS	"insect products and insect-based products"	1, 2, 6, 21, 23
Tan et al. (2016)	976	Netherlands	OS	WTP	P	S	insect stew, insect curry, insect brownies, insect cakes	6, 23, 26, 31
Tan et al. (2015)	103	Netherlands	E	WTE	R	S	insect patties	26
Tan et al. (2017)	135	Netherlands	OS	WTP	R	S	whole insects, insect meat balls, insect shakes	26, 34
Verbeke (2015)	368	Belgium	OS	WTA	D	NS	"insects as substitute for meat"	1, 2, 3, 10, 20
Verneau et al. (2016)	282	Denmark, Italy	E	WTE	R	S	insect chocolate bars	20, 27
Videbæk and Grunert (2020)	975	Denmark	E	WTA	D	S	whole insects, pureed insects, insects with fish, insect bread	6, 8, 18, 22

Note. The measured WTC correlate's enumeration can be found in Table 16 and Figures 15–17. Data collection: E = experiment, PPS = paper pencil survey, CAS = computer-administered survey, OS = online survey. WTC measures: WTT = willingness to try, WTE = willingness to eat, WTP = willingness to pay, WTA = willingness to adopt. Insect food presentation: D = description, P = picture, R = real product. Insect food type: S = specific insect food product (e.g., insect patties), NS = no specification given regarding the insect as food (e.g., "insects as food," "edible insects").

4.2.3. Selection of relevant effect sizes

From the 37 records included in this review, 195 correlations between the WTC and 49 variables (WTC correlates) were extracted. However, we decided to exclude the WTC correlates (n = 15) measured by only one study because doing so would not have allowed the calculation of a mean effect size. Ultimately, this analysis included 180 correlations between the WTC insects and 34 WTC correlates.

These 34 WTC correlates (Table 16) can be divided into the following three groups: "Group 1: Sociodemographic variables and general attitudes" (*gender*, *age*, *education*, *environmental concern*, and *health concern*) (Figure 15), "Group 2: Variables related to eating" (e.g., *food neophobia*, or *meat consumption*) (Figure 16), and "Group 3: Variables related to eating insects" (e.g., *disgust at eating insects*, or *perceived sustainability of insects as food*) (Figure 17).

4.2.4. Data analysis

The current analysis reports all effect sizes as Pearson's r correlation coefficients. Some articles (n = 5) reported more than one correlation for the same relationship between WTC and a certain WTC correlate. For example, some studies reported the correlation between WTC and a certain WTC correlate for a vegetarian and a non-vegetarian group (e.g., Elorinne et al., 2019). For these cases, a composite correlation coefficient was calculated based on the data provided by the authors (Hunter & Schmidt, 2004). Some articles (n = 2) contained multiple studies (e.g., Chan, 2019). If only one study within a multi-study article was relevant, only the study information and results of the relevant study were included. If multiple studies within one multi-study article were relevant, composite correlation coefficients (Hunter & Schmidt, 2004) and the average sample size across the studies were calculated.

To estimate mean effect sizes and their variability in the metanalysis, the random effects method (Hedges & Olkin, 2014) was applied because random differences across studies were likely (significant Q statistic, Table 16). This methodology incorporates the influence of sample size and weighs effect sizes accordingly. Baujat plots and corresponding diagnostics were inspected to check for potential outliers and influential cases. Funnel plots, Egger's regression tests, and the Rank correlation tests indicated that publication bias was not influential. The resulting mean effect sizes (Table 16) were interpreted according to Funder and Ozer (2019), whereby $\bar{r}$ = .10 represents a small effect, $\bar{r}$ = .20 a medium effect, and $\bar{r}$ = .30 a large effect. Corresponding confidence and credibility intervals were given to communicate the precision (or uncertainty) of the summary estimate. Table 16 also depicts heterogeneity analyses. A

significant Q statistic was interpreted as evidence that heterogeneity is present across the reported results of the studies. I^2 was reported as a quantification of these inconsistencies across studies and interpreted according to Deeks et al. (2011), whereby an I^2 of 0%–40% indicates unimportant heterogeneity, an I^2 of 30%–60% indicates moderate heterogeneity, an I^2 of 50%–90% indicates substantial heterogeneity, and an I^2 of 75%–100% indicates considerable heterogeneity. Similarly, $\boldsymbol{\tau}$ was reported to indicate the extent of variation, or heterogeneity, among the reported results of the studies. Forest plots are presented to display the (composite) correlation coefficients of the WTC correlates for each of the three groups (Figures 4.2–4.4). Lastly, meta-regressions were conducted to test whether certain study characteristics had explanatory value concerning heterogeneity.

All data analyses were conducted in R (RStudio Team, 2015) with the "metafor" (Viechtbauer, 2010) and "robumeta" (Fisher & Tipton, 2015) packages, while Figures 4.2–4.4 were created using Tableau (Tableau Software Inc., 2003).

4.3. Results

4.3.1. Descriptive study characteristics

Table 15 shows the most important study characteristics. Most studies were surveys (online, paper-pencil or computer-administered) conducted with participants from European countries. Only eight studies involved an experiment, and only six studies involved participants not from Europe (e.g., the US, India, China, or Thailand). As the willingness to consume measure, the majority (n = 21) of the studies assessed WTE, while seven studies assessed WTP, five studies assessed WTT, and four studies assessed WTA. To assess these measures, mostly descriptions (n = 14) or pictures (n = 15) of the insect foods in question were presented, while in eight studies, the real insect food product was presented to participants. For most studies (n = 29) participants were asked to indicate their willingness to consume specific insect-based food products (e.g., mealworm patties, insect-flour protein bars, or deep-fried crickets). In the other eight studies, no specific type of insect food was given: Participants were asked to indicate their willingness to consume "foods of insect origin" or "insect-based foods."

Table 16. Summary of the meta-analysis for the 34 WTC correlates.

WTC correlate	*k*	*N*	$\bar{r}$	95% CI	80% CR	*Q*	τ	I^2
Group 1: Sociodemographic variables and general attitudes								
1 Gender (0 = m, 1 = f)	20	10323	-.14	[-.16, -.27]	[-.23, .03]	44.42**	0.05	53.68
2 Age	17	9847	< **.00**	[-.05, .04]	[-.19, .18]	61.23**	0.09	82.73
3 Education	13	8919	**.04**	[-.02, .10]	[-.17, .25]	99.01**	0.11	87.96
4 Environmental concern	3	1319	**.05**	[-.01, .12]	[-.05, .16]	3.38	0.04	42.37
5 Health concern	2	1335	**-.03**	[-.14, .08]	[-.20, .14]	3.28	0.07	69.47
Group 2: Variables related to eating in general								
6 Food neophobia	21	8919	-.33	[-.37, -.26]	[-.53, -.07]	179.15**	0.13	88.56
7 Meat consumption	12	6396	.08	[.04, .11]	[-.01, .17]	21.61*	0.12	50.16
8 Food sensation and innovation seeking	6	3058	.29	[.25, .32]	[.25, .32]	2.59	< 0.01	< 0.01
9 Importance of taste for food choice	4	4164	**.01**	[-.09, .12]	[-.22, .24]	45.57**	0.11	91.73
10 Importance of sustainability for food choice	3	3961	**.10**	[-.01, .22]	[-.12, .32]	19.17**	0.10	91.99
11 Importance of healthiness for food choice	3	3081	.05	[-.14, .23]	[-.30, .39]	50.26**	0.16	95.57
12 Importance of convenience for food choice	3	3081	**.06**	[-.09, .21]	[-.23, .34]	39.61**	0.13	93.52
13 Intention to reduce meat consumption	3	1200	**.04**	[-.10, .18]	[-.22, .30]	12.86*	0.12	83.28
14 Food disgust	3	1200	-.44	[-.50, -.36]	[-.54, -.32]	4.16	0.05	52.00
15 Importance of affordability for food choice	2	2770	**.07**	[-.14, .28]	[-.29, .41]	30.60**	0.15	96.73
16 Food fussiness	2	2392	-.21	[-.26, -.15]	[-.28, -.13]	1.71	0.03	41.64
17 Importance of social acceptability for food choice	2	1987	.36	[.33, .40]	[.33, .40]	0.59	< 0.01	< 0.01
18 Disgust sensitivity	2	1485	-.23	[-.37, -.07]	[-.45, .02]	8.35*	0.11	88.04
19 Food technology neophobia	2	1013	-.27	[-.32, -.20]	[-.32, -.20]	0.72	< 0.01	< 0.01

Note. Table continues on next page.

Table 16. *(continued)*

Group 3: Variables related to eating insects								
20 Familiarity with the concept of eating insects	14	5899	**.10**	[-.11, .31]	[-.63, .74]	883.85**	0.42	98.61
21 Experience with eating insects	12	5786	.35	[.22, .46]	[-.12, .69]	276.23**	0.24	96.45
22 Disgust at eating insects	12	4460	-.53	[-.66, -.36]	[-.86, .13]	543.89**	0.35	97.79
23 Perceived tastiness of insects as food	11	5363	.55	[.33, .71]	[-.31, .91]	600.68**	0.46	97.99
24 Perceived social acceptability of insects as food	7	3463	.35	[.24, .45]	[.05, .59]	52.69**	0.15	90.68
25 Perceived risk of insects as food	6	2669	-.33	[-.44, -.21]	[-.58, -.02]	44.04**	0.15	90.68
26 Preference for carrier food [1]	6	1906	.10	[.05, .14]	[.05, .14]	3.17	< 0.01	< 0.01
27 Perceived sustainability of insects as food	5	2788	.57	[.29, .75]	[-.17, .89]	335.37**	0.38	98.69
28 Perceived ethicalness of insects as food	4	2976	**.27**	[-.01, .51]	[-.35, .72]	162.04**	0.30	98.44
29 Perceived healthiness of insects as food	4	2332	.42	[.37, .46]	[.33, .49]	5.26	0.04	42.48
30 Perceived nutritiousness of insects as food	4	2056	.32	[.20, .42]	[.08, .52]	16.72*	0.11	85.03
31 Preference for visibility of insects in food	3	1885	.41	[.19, .58]	[.02, .71]	39.21**	0.20	95.83
32 Perceived naturalness of insects as food	3	1476	.41	[.20, .57]	[-.01, 0.70]	40.34**	0.19	94.79
33 Perceived visual appeal of insects as food	3	1236	**.27**	[.00, .50]	[.26, .68]	40.16**	0.24	95.54
34 Familiarity with carrier food[1]	2	915	**.35**	[-.14, .69]	[-.56, .87]	127.17**	0.44	97.93

Note. Sorted by k and N (within each group). Significant $\bar{r}$ in bold. k = number of studies contributing to meta-analysis; N = total sample size; $\bar{r}$ = mean observed correlation; CI = confidence interval around $\bar{r}$; CR = credibility interval around $\bar{r}$; Q = test for homogeneity, $\boldsymbol{\tau}$ = estimated standard deviation of the distribution of the true effects across studies; I^2 = proportion of heterogeneity due to between-study differences; [1]"carrier food" refers to the food product that contains the edible insect (e.g., a burger patty or a chocolate bar). * $p < .05$, ** $p < .001$.

4.3.2. Results of the meta-analysis

Heterogeneity analysis.

For 25 of the 34 WTC correlates, the Q statistic provided evidence for significant heterogeneity across studies. Correspondingly, the I^2 and τ results for these WTC correlates were high (with I^2 values ranging from 53% to 96%), indicating that the effect sizes extracted from the studies varied greatly. For nine of the 34 WTC correlates, there was no evidence for significant heterogeneity across studies. However, because most of these low-heterogeneity WTC correlates had a low number of contributing studies ($k < 6$), there is a high level of uncertainty regarding these results (Deeks et al., 2011).

Mean estimated effect sizes.

Group 1: Sociodemographic variables and general attitudes.

This group consists of WTC correlates 1–5 (Figure 15). There was relatively large heterogeneity concerning the reported effect sizes for the sociodemographic variables and *education*, as well as the attitudes *environmental concern* and *health*. This heterogeneity was especially pronounced for *education*. Considering the fact that the mean effect sizes for these four WTC correlates were also close to 0, these results suggest there is no correlation between these variables and WTC insects. The number of contributing studies should be taken into account when considering these results however: While inconsistent effects of *age* and *education* were found across a large number of studies, the mean effects of the attitudes (i.e., *environmental concern* and *health concern*) were calculated from only two to three studies. It is therefore uncertain whether the inconsistent effect of the attitudes would persist if there were more data from more studies to draw from.

Within this group, *gender* was the only variable with any correlation to WTC. For this variable, the heterogeneity across a large number of studies was relatively low, and a small mean effect size was calculated. The female participants in the identified literature, therefore, were consistently less willing to consume insects than the male participants; however, this effect was small.

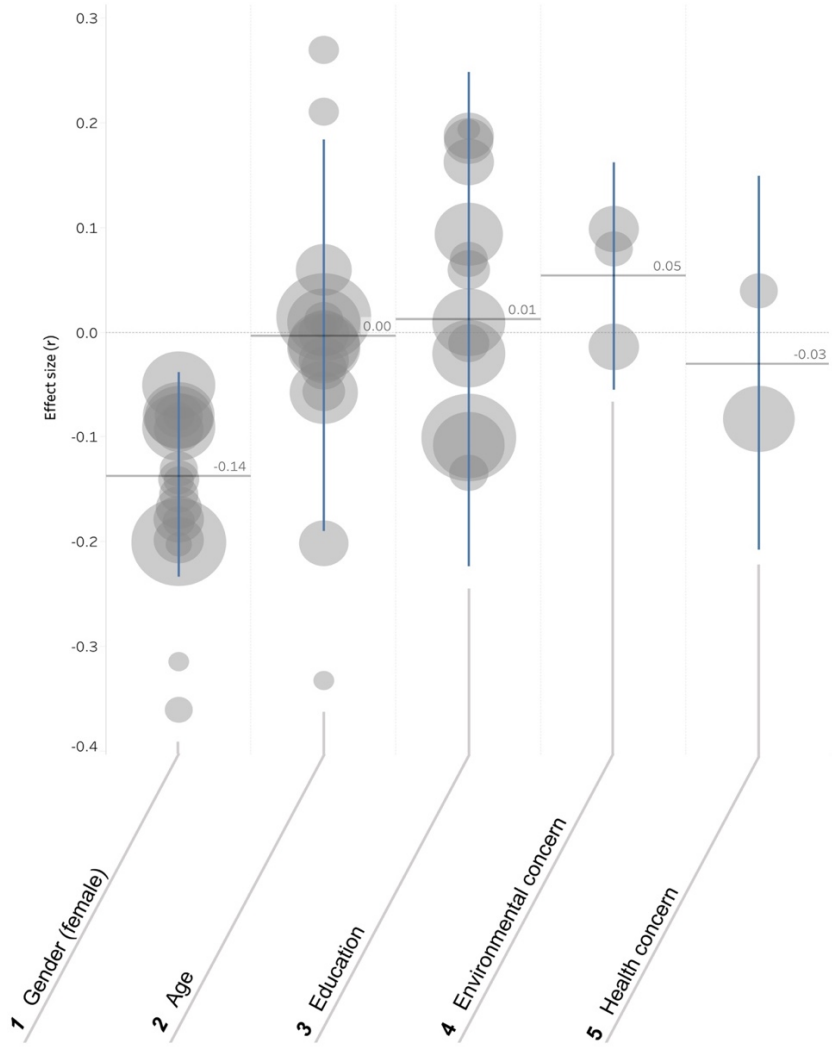

Figure 15. Forest plot of WTC correlates in "Group 1: Sociodemographic variables and general attitudes." Error bars represent the 80% CR credibility intervals of the effect size. Each circle represents one study: The location of the circle on the y-axis represents the effect size, while the size of the circle indicates the study sample size. Sorted by *k* (i.e., the number of studies contributing to mean effect size)

Group 2: Variables related to eating in general.

This group consists of WTC correlates 6–19 (Figure 16). Most of the food choice motives (*importance of taste, healthiness, sustainability, convenience,* and *affordability for food choice*) had mean effect sizes close to 0, suggesting no link between these variables and consumers' WTC insects. Interestingly, the *importance of social acceptability for food choice* was the only food choice motive strongly correlated with WTC. Again, however, it should be taken into account that all of these mean effect sizes only included two or three studies. Thus, there is little certainty that the calculated mean effect sizes represent the "true" mean effect sizes for these variables.

In contrast to the food choice motives, we have *food neophobia* and *food sensation and innovation seeking*. The mean effect of these WTC correlates can be considered large, and it included a relatively large number of homogeneous correlation coefficients, indicating a high level of certainty that these factors are closely linked to WTC insects. Such large mean effect sizes were also found for the related constructs *food technology neophobia* and *food fussiness.* However, the number of contributing studies for these factors was small, limiting the credibility of these results. Also, WTC correlates related to disgust (*food disgust* and *disgust sensitivity*) had large negative mean effect sizes. Again, however, the number of contributing studies for these variables was small.

Overall, therefore, it appears that more general food choice motives (*importance of taste*, *sustainability*, *healthiness*, *nutritiousness*, and *convenience for food choice*) are weakly linked to WTC insects. Variables, however, which are related to the newness and acceptability of food (*food neophobia*, *food sensation and innovation seeking*, *food technology neophobia*, *food fussiness,* and the *social acceptability of food*), as well as affect (*food disgust* and *disgust sensitivity*), are more strongly linked to WTC insects.

Group 3: Variables related to eating insects.

In this group (Figure 17), the WTC correlates with the largest mean effect sizes were the *perceived sustainability of insects as food* ($\bar{r}$ = .57), the *perceived tastiness of insects as food,* and *disgust at eating insects as food* ($\bar{r}$ = -.53). While the disgust factor is unsurprisingly the greatest barrier to the acceptance of entomophagy, the awareness of insects' environmental benefits—more so than the awareness of their health and nutrition related benefits—appears to be the most important driver of entomophagy acceptance. Furthermore, the results suggest that making insect-based food appear tasty to consumers could be highly important for consumers' WTC insects.

Interestingly, the reported effect sizes of *familiarity with the concept of eating insects* were very heterogeneous ($\bar{r}$ = .10) across the identified literature, which may be a reason for the small mean effect size that was obtained for this WTC correlate.

Other WTC correlates that were strongly correlated with WTC and also had a relatively large number of contributing studies were *experience with eating insects* ($\bar{r}$ = .35, k = 12) and the *perceived social acceptability of insects as food* ($\bar{r}$ = .35, k = 7). The other variables from this group (i.e., WTC correlates 31–34) only include two or three studies; the credibility of the calculated mean effect for these variables is therefore highly limited.

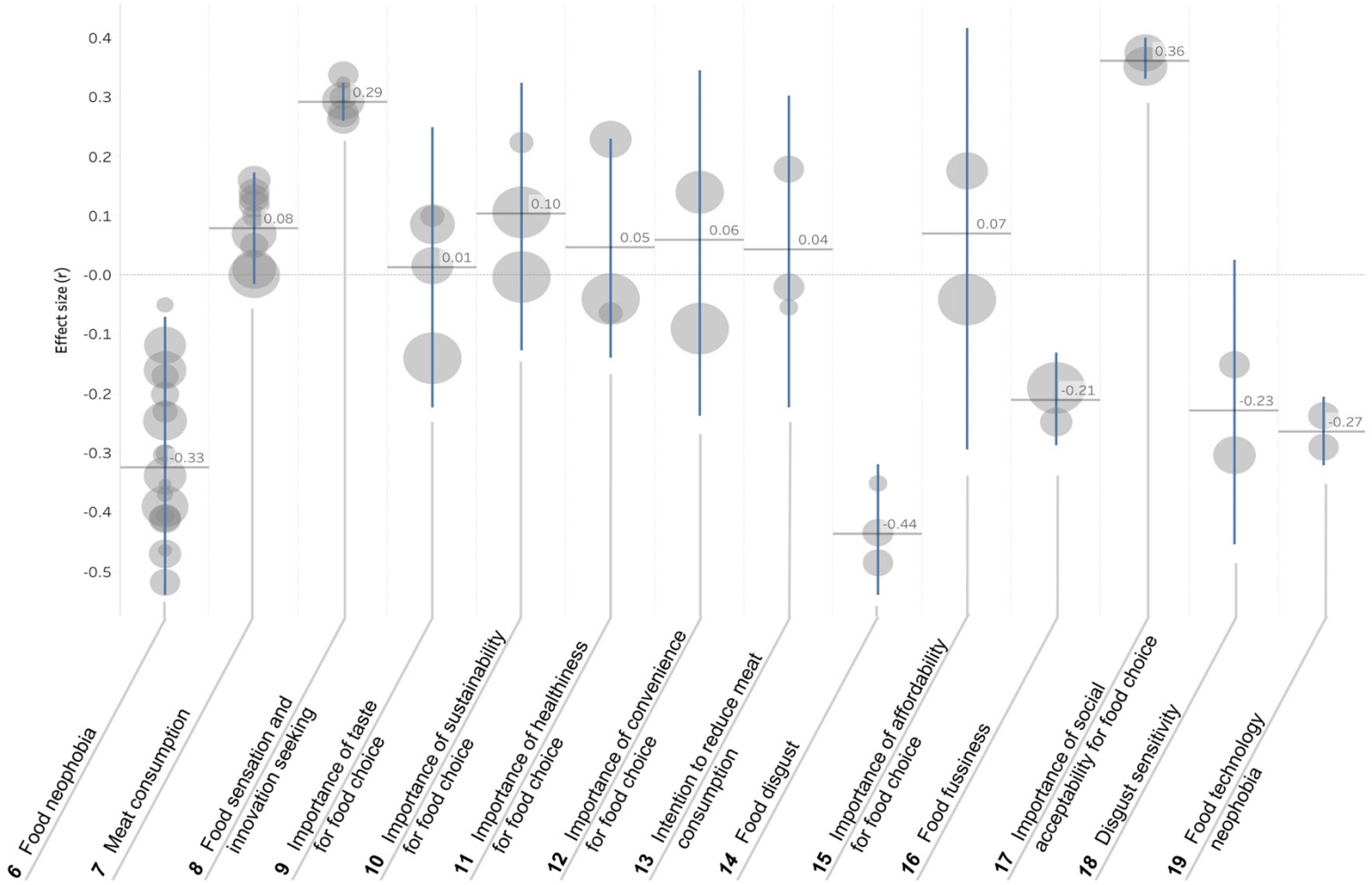

Figure 16. Forest plot of the WTC correlates in "Group 2: Variables related to eating in general." See Figure 15 for further description.

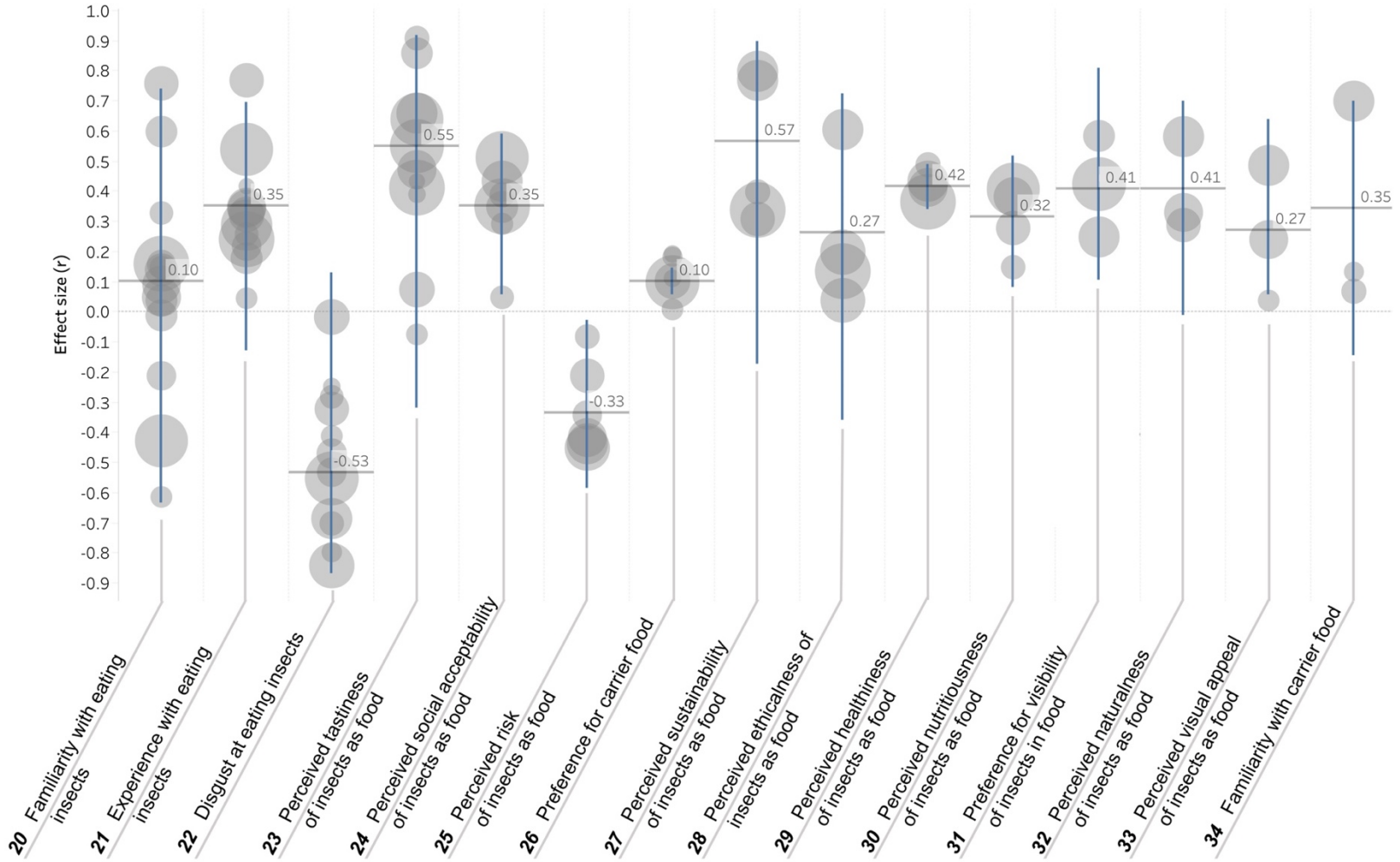

Figure 17. Forest plot of the WTC correlates in "Group 3: Variables related to eating insects." See Figure 15 for further description.

Meta-regressions.

Meta-regressions were conducted to determine whether the study characteristics described in Table 15 can explain the high levels of heterogeneity shown for many WTC correlates. Specifically, the moderating effects of the type of data collection (experiment, paper pencil survey, computer-administered survey, or online survey), the type of WTC measure (WTT, WTE, WTP, or WTA), the insect food presentation (description, picture, or real product) and the insect food type (specific insect food product or non-specific type of insect food) were tested. These meta-regressions were conducted for WTC correlates fulfilling two specifications, as recommended by Deeks et al. (2011): A meta-regression was only performed for WTC correlates that had considerably high heterogeneity (i.e., $I^2 > 75\%$) and also included ten or more studies (i.e., $k > 10$). Thus, the WTC correlates examined through this procedure were *gender*, *age*, *education*, *food neophobia*, *familiarity with the concept of eating insects*, *experience with eating insects*, *disgust at eating insects*, and the *perceived tastiness of eating insects*.

As can be seen in Table 17, moderating effects were found for two WTC correlates. Firstly, the correlation between WTC and *familiarity with the concept of eating insects* was moderated by insect food presentation, explaining 27.5% of variance. Specifically, presenting participants with pictures of the insect food and the real insect food product negatively affected the link between the correlate and WTC (as opposed to presenting only a description). Secondly, the correlation between WTC and the *experience with eating insects* was moderated by insect food type, explaining 40.6% of variance. Specifically, asking participants about specific insect foods negatively affected the link between the correlate and the WTC (as opposed to not mentioning any specific type of insect food).

Table 17. Results of meta-regressions.

WTC correlate	Moderator	*k*	β	*SE*	*z*	95% CI	R^2
Familiarity with the concept of eating insects	Insect food presentation	14					
	- *Picture (vs. description)*		-.55*	0.22	-2.44	[-1.10, -.02]	27.5%
	- *Real product (vs. description)*		-.56*	0.28	-2.44	[-.99, -.11]	27.5%
Previous insect consumption	Insect food type	12					
	- *Specific (vs. no specification given)*[1]		-.47*	0.14	3.27	[-.76, -.18]	40.6%

Note. *k* = number of studies contributing to meta-regression; β = regression estimate*; SE* = standard error*; z* = z-value; 95% CI = confidence interval around β; R^2 = percentage of explained variance. [1]Specific insect food products: e.g., "insect patties" or "insect chocolate bars"; No specification given concerning the type of food product: e.g., "insects as food" or "edible insects." * $p < .05$.

4.4. Discussion

4.4.1. Main findings and implications

To better understand the generally low willingness to consume insects, we synthesized the effect sizes of various WTC correlates reported in previous studies. We present not only an overview of factors related to entomophagy acceptance—as previous qualitative reviews have already done—but also estimates of their effect sizes. Although there was a high level of heterogeneity for some WTC correlates, our results provide an approximate quantification of the importance of various WTC correlates (both as individual factors and in comparison with one another) and certain study characteristics of past entomophagy acceptance research (in terms of moderating effects).

Our main conclusion is that affect-based factors are most relevant to the WTC insects. For instance, the "classical" food choice motives (Steptoe et al., 1995) (i.e., *the importance of*

sustainability, *healthiness*, *convenience,* and *affordability for food choice*), which are not necessarily related to affect but rather to more general food quality measures, were hardly correlated with WTC ($\bar{r}$ = .01-.10). Instead, across all 37 included studies, the factors with consistently large effect sizes ($\bar{r}$ = -.33-.55) were factors strongly related to affect. Specifically, factors related to the fear of the unfamiliar, disgust, pleasure, and social acceptability (i.e., *food neophobia, food technology neophobia*, *food disgust*, *food disgust sensitivity*, *food fussiness*, *disgust at eating insects*, the *perceived risk of insects as food,* the *perceived social acceptability of insects as food*, and the *perceived tastiness of insects as food*). Evolutionarily, these factors stem from human protection mechanisms to prevent the consumption of potentially harmful substances (Chapman & Anderson, 2012; Martins & Pliner, 2006; Tuorila et al., 1994). Naturally, these can also be barriers to other novel foods, such as genetically modified foods (Costa-Font et al., 2008), cultured meat (Siegrist & Hartmann, 2020), or other novel meat substitutes, e.g., mycoprotein (Hartmann & Siegrist, 2017a). Compared to most of these foods, however, consumers appear to be more averse toward insects (Dupont & Fiebelkorn, 2020; Grasso et al., 2019).

Approaches to increasing entomophagy acceptance.

Pliner and Salvy (2006) propose various approaches to increase the acceptance of novel foods. In combination with our findings, these could be applicable to entomophagy, potentially to varying degrees of effectivity.

The first and perhaps most effective approach is the reduction of the main barriers to entomophagy acceptance—*food neophobia* ($\bar{r}$ = -.33), *disgust* ($\bar{r}$ = -.53, $\bar{r}$ = -.44), and the *expected (unpleasant) taste of insects* ($\bar{r}$ = -.55). In general, *food neophobia* and *disgust* are decreased through gradual and/or early exposure to unfamiliar food (Birch et al., 1987; Loewen & Pliner, 1999; Pliner, 1982; Sullivan & Birch, 1990; Wardle et al., 2003). The emergence of insect food products in supermarkets, “bug banquets” (Looy & Wood, 2006), and the media (Legendre et al., 2019) have all contributed to the public’s steady familiarization with entomophagy. Indeed, we found that *familiarity with the concept of entomophagy* ($\bar{r}$ = .10), and *previous insect consumption* ($\bar{r}$ = .35) both positively impact WTC (Gere et al., 2017; Hartmann et al., 2015; Legendre et al., 2019). As a next step, entomophagy could be promoted specifically to children. Dupont and Fiebelkorn (2020), who conducted one of the first entomophagy acceptance studies with a sample of children and adolescents, recommend tasting sessions, teaching units, and methods for including edible insects in class, e.g., in biology or geography class (Fiebelkorn & Kuckuck, 2019; Fiebelkorn & Puchert, 2018). As an emotion connected to

the oral sense, disgust is linked to taste (Rozin et al., 2009). Pelchat and Pliner (1995) found that providing individuals with the verbal information that a novel food tasted good increased their willingness to try it. Thus, to combat the *perceived (unpleasant) taste of insects as food*, insect food advertisements and packaging could explicitly create positive expectations. Future studies should examine how familiarization with and positive expectations regarding edible insects can be fostered more concretely.

As a second approach, the benefits of insects as food should be emphasized. We found that the *perceived sustainability of insects as food* ($\bar{r}$ = .55) appears to be their most compelling benefit. In second and third places, consumers are also compelled by the *perceived healthiness* ($\bar{r}$ = .42) and *nutritiousness* ($\bar{r}$ = .32) *of insects as food*. Insects may therefore have the most success in the "green consumer" market (e.g., as insect-based meat substitutes for environmentally motivated consumers) and, alternatively, among fitness and health-oriented consumers (e.g., insect protein bars and shakes, or insects as a "healthier" meat alternative). Indeed, informing consumers about either the individual or societal benefits of edible insects differentially impacts WTC (La Barbera et al., 2018; Verneau et al., 2016). More research on this topic is needed to better understand the various insect consumer segments (Brunner & Nuttavuthisit, 2019). However, strong emotional aversions may block information effects (Martins et al., 1997; Pliner & Salvy, 2006). Thus, as Pliner and Salvy (2006) have concluded, cognitive interventions tend to have limited impact on affect-based food aversions. In the case of entomophagy, therefore, emphasizing the positives of edible insects ("Approach 2") may be less effective than directly combatting the negative affective factors ("Approach 1").

Lastly regarding Approach 3, humans not only exhibit aversion but also curiosity regarding novel foods (Rozin & Rozin, 1981). Indeed, we found that consumers who are *food sensation and innovation seeking* were likely to have a higher WTC ($\bar{r}$ = .29), a result in line with the finding that *food neophobia*, *food technology neophobia*, and the *importance of social acceptability for food choice* are all negatively correlated with WTC. Brunner and Nuttavuthisit (2019) propose that insect food products could be marketed as something unique and exciting, e.g., at special "insect bars" similar to sushi bars.

4.4.2. Other findings and implications

In accordance with past research (e.g., Lammers et al., 2019), we found certain sociodemographic variables to be unrelated to entomophagy aversions. The effects of *age* ($\bar{r}$ < .00) and *education* ($\bar{r}$ = .04) were highly inconsistent across studies, with mean effects sizes

close to 0. There was a negative mean effect for *gender*, i.e., being female ($\bar{r}$ = -.14); however, this effect was small and could have been influenced by the tendency of women to generally have higher disgust sensitivity than men. Entomophagy acceptance, however, varies cross-culturally (Gómez-Luciano et al., 2019; Verneau et al., 2016), especially when comparing Western with Asian countries (Brunner & Nuttavuthisit, 2019; Hartmann et al., 2015; Ruby & Rozin, 2019; Ruby et al., 2015). We were not able to investigate national differences, because many studies with non-Western participants had to be eliminated during the literature search and, as a result, most of the included studies consisted of primarily Western samples. A sociocultural perspective should be incorporated in future syntheses of entomophagy acceptance research.

In addition to sociodemographic variables, an individual's dietary behavior may also predict the WTC insects. Indeed, *meat consumption* was positively associated with WTC. This estimated effect, however, was based on studies including vegans and vegetarians. Vegans and vegetarians tend to be less willing to eat insects due to animal welfare concerns (Elorinne et al., 2019), and their inclusion may have thus influenced our estimated effect size. Therefore, our findings do not represent how omnivore's WTC insects correlates with their meat consumption and—more importantly—*their intention to reduce* meat consumption. Dupont, Hagedorn and Fiebelkorn (pers. comm.) and Verbeke (2015), for example, found that individuals who intended to or had already reduced their meat consumption were more WTC insects, perhaps because they saw them as a sustainable meat replacement. Despite this, Lammers et al. (2019) showed that omnivores would prefer to merely try insects as opposed to adopting them as meat-substitutes. More studies focused on insects specifically, as meat-substitutes are needed because it may be easier to encourage the "switch" from meat to insects than persuade consumers to adopt insects into their diet without any further framing.

Multiple studies show that consumers prefer edible insects to be invisible and processed rather than visible and whole (Gmuer et al., 2016; Hartmann & Siegrist, 2016; Orsi et al., 2019). Unfortunately, the experimental design of most of these studies did not allow us to calculate an effect size estimating how *the degree of processing* impacts WTC insects. Still, we found that the *preference for the visibility of insects in food* ($\bar{r}$ = .41) was positively correlated with WTC.

Both the *preference for the carrier food* ($\bar{r}$ = .10) and the *familiarity with the carrier food* ($\bar{r}$ = .35)—the "main" food product carrying the insect ingredient—were positively correlated with WTC. However, only a few studies (Elorinne et al., 2019; Hartmann & Siegrist,

2016; La Barbera et al., 2018; Menozzi et al., 2017; Tan et al., 2015; Tan et al., 2016; Tan et al., 2017) contributed to these findings. Thus, carrier food variables should be investigated more in depth, for example, the product type, e.g., pasta vs. chocolate bar (Lombardi et al., 2019; Orsi et al., 2019); the flavor, e.g., savory vs. sweet (Schäufele et al., 2019; Tan et al., 2016); or the serving context, e.g., snack vs. meal vs. dessert (Brunner & Nuttavuthisit, 2019; Elorinne et al., 2019).

In the same vein, other variables related to marketing and product development must be explored in more depth, such as price (Lombardi et al., 2019), convenience (Brunner & Nuttavuthisit, 2019; Elorinne et al., 2019), insect species (Fischer & Steenbekkers, 2018; Rozin & Ruby, 2019), and the packaging (Baker et al., 2016). The "classical" variables of entomophagy, as Lammers et al. (2019) call them, such as *food neophobia* or *disgust*, have been explored sufficiently, and future research should be more market oriented.

Meta-regression results.

The meta-regressions showed that study characteristics such as insect food presentation may have moderating effects. Specifically, the positive effects of *familiarity with entomophagy* and *previous insect consumption* on WTC insects were stifled when participants were shown (A) specific products vs. non-specific products (β = -.47); and (B) verbal descriptions of products vs. actual products (β = -.56) vs. pictures products (β = -.55). Baker et al. (2016) found similar study characteristics to be influential because they showed that providing images of processed (vs. whole) insects positively influenced perceptions in retail settings, while providing vague (vs. explicit) descriptions did so in restaurant settings. In our analysis, moderating effects were not found for the other study characteristics. However, because meta-regressions were conducted for only a small number of WTC correlates due to methodological restrictions, other study characteristics—such as offering tasting samples (Mancini, Sogari et al., 2019; Megido et al., 2016; Tan et al., 2015) or asking participants to try vs. buy insects as food (Tan et al., 2016)—may actually have moderating effects as well.

Limitations.

Regarding the main limitation, many studies and effect sizes concerning entomophagy acceptance could not be included in this analysis due to the inclusion criteria. Our findings therefore do not include the entirety of the existing literature on this topic. Specifically, we only included studies that measured WTC edible insects (and not, for example, the sensory liking of edible insects) and studies for which we were able to obtain these effects as Pearson's *r*. Furthermore, we only included WTC correlates measured in at least two papers. For example, the impact of consumers' attitudes toward organic production methods (Kornher et al., 2019),

purchase activism (Legendre et al., 2019), and nutritional knowledge (Brunner & Nuttavuthisit, 2019) on the WTC insects have only been measured by single studies and were therefore not included in this analysis. These may be interesting variables for future research to consider.

Furthermore, many other study characteristics which we did not test for could have potential moderating effects. For example, the sample age group (i.e., if the sample consisted of students/general population, or young adults/adults/senior citizens), or the date of data collection (as opposed to the date of publication) could have been of relevance.

4.4.3. Conclusion

Aversions to edible insects appear to be most strongly linked to affect-based factors (i.e., disgust, or neophobia), which are best reduced through gradual and/or early exposure to entomophagy. Unsurprisingly, therefore, steady familiarization over a longer period of time is the perhaps best strategy to foster the acceptance of entomophagy in the long term. Concerning interventions that may already show effects in the short term, information-based approaches (e.g., emphasizing the benefits of insects as food) may convince consumers to at least try edible insects. However, the influence of these cognitive factors may be blocked by the strong emotional insect aversions, limiting the success of insects with consumers compelled "merely" by their sustainability and health related benefits. As an alternative approach, human curiosity appears to increase the WTC insects. It is likely therefore that food sensation and innovation seekers could be among the first adopters of entomophagy.

Many general psychological factors have been investigated comprehensively in the context of entomophagy acceptance. Future research should focus on the nuances of how to concretely bring insects to consumers. With this, it becomes even more important that researchers consider the influence of certain study characteristics (e.g., the utilized stimuli) to ensure unbiased results. Furthermore, future research should investigate beneficial approaches to the product development and marketing of specific insect-based products.

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Chapter 5

Novel Microalgae Foods

Novel microalgae foods: Which product attributes increase Singaporean consumers' acceptance?

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Abstract

Microalgae (MA) are a nutritious and sustainable new source of protein that could significantly contribute to meeting the world's growing caloric demands. However, little is known about MA's acceptance among consumers. The current online study investigated which attributes of an MA-based food product increase acceptance in a Singaporean sample (N = 578). The most frequent associations with the term "MA-based foods" were "vegetarian foods" and "meat substitutes." Meat-consumption reducers had more positive associations than omnivores. We compared participants' perception of MA, beef burgers, chicken, tofu, plant-based burgers, seaweed, and insects. MA and plant-based burgers were perceived similarly (e.g., as highly modern and more environmentally friendly than beef burgers and chicken). Tofu and seaweed were rated as the most tasty, festive, natural, environmentally friendly, healthy, and cheap foods. Participants were asked to rate how convincing certain MA attributes were in terms of the purchase of MA-based products. The attributes were rated as follows, from most to least convincing: "innovative" / "environmentally friendly" / "healthy" / "nutritious" / "high in protein." The willingness to buy (WTB) MA-based meat/fish substitutes (e.g., sausage and fish balls) and non-substitutes (e.g., noodles and bread) was higher for consumers who were young, had a high income, high sustainability concerns, high health concerns, low food neophobia, reduced their meat consumption, and displayed a higher social image eating motivation. Our results suggest that, to increase Singaporean consumers' acceptance, an MA-based food product should ideally be a meat/fish substitute; be aligned with traditional Asian cuisine; be framed as environmentally friendly, innovative, and trendy; and have emphasized health benefits.

5.1. Introduction

Global food demand is expected to double within the next thirty years (Van Dijk, Morley et al., 2021). Both our food security and the environment are threatened, with animal protein production being the main food-related driver of climate change (Aiking, 2011; Frehner et al., 2022; Lamb et al., 2016; Leip et al., 2015). The situation is especially problematic in Asia, which is home to 60% of the world population. Caloric demands are increasing more quickly in Asia than anywhere else (UN Food and Agriculture Organization (FAO), 2018), and extreme urbanization, and the lack of urban food production systems are additional threats to the food supply. At the same time, Asian countries—many of which have low per capita incomes—are among the most affected by climate change (Fankhauser & McDermott, 2014).

Microalgae are a promising protein source that could contribute to our future food supply (Caporgno & Mathys, 2018). While *macro*algae are plant-like structures also referred to as seaweed, *micro*algae are single-celled organisms. Both these forms of algae have long been part of the human diet. However, while seaweeds have been cultivated and harvested for centuries, the large-scale production of MA has only recently been possible, enabling its use as an innovative ingredient in various food products (Spolaore et al., 2006).

The more widespread dietary adoption of MA would have benefits for both human health and the environment. MA are rich in high-quality protein and other compounds with valuable health benefits (Becker, 2007; Canelli et al., 2020). Furthermore, they can be cultivated in seawater, on non-arable land, and with minimal freshwater (Caporgno & Mathys, 2018), and they also require much less land as compared to animal-based and even many plant-based proteins (e.g., soy bean, pulse legumes, wheat, or pea protein) (De Vries & De Boer, 2010; Smetana et al., 2017; Van Krimpen et al., 2013). In comparison to seaweed, MA are superior in terms of biomass yield and lipid content (Cai et al., 2013; Toor et al., 2018). Thus, MA are not only more sustainable than animal proteins, but also superior in terms of sustainability and nutrition as compared to other alternative proteins (e.g., soy, pulses, and seaweed). The feasibility of urban MA production could be one way to ensure the continuation of the food supply in an increasingly urbanized world.

5.1.1. Consumer acceptance of algae

Seaweed (i.e., macroalgae) has long been part of the global food system, even though its popularity varies from culture to culture. In many Asian countries, particularly Japan, Korea, and China, seaweed is enjoyed in all parts of the diet, from main courses to soups, salads,

snacks, and supplements (Gajaria & Mantri, 2021). However, food safety has been a concern, especially regarding wild-harvested seaweed (Gajaria & Mantri, 2021). In Western countries, seaweeds are much more rarely consumed, as they usually only appear in Asian dishes (e.g., sushi) and in premium "health" or niche foods (e.g., spirulina supplements and algae bread) (Yesuraj et al., 2022). Even though Western consumers may be skeptical about the sensory properties of seaweed, they are generally open to eating seaweed-based foods, especially when the health, nutritional, and innovative aspects of the products are emphasized (Anusha et al., 2022; Birch et al., 2019; De Boer et al., 2013; Losada-Lopez et al., 2019; Michel et al., 2021; Palmieri & Forleo, 2020).

While seaweed (i.e., macroalgae) is familiar around the globe, little is known about the acceptance of MA. Most consumers know very little about MA and have never tried such products before (Lafarga et al., 2021). The few who have heard of MA claim to be interested in eating such products in the future (Lafarga et al., 2021), especially those who are young and have significant sustainability and health motivations (Grahl et al., 2018; Grasso et al., 2019; Moons et al., 2018). These consumers also appear to be aware of the benefits of MA because they perceive MA to be environmentally friendly, healthy, nutritious, and safe (Lafarga et al., 2021). However, there is skepticism regarding MA's sensory appeal (Grasso et al., 2019). Consumers tend to be unwilling to sacrifice taste and pay a premium price, even for an environmentally friendly or healthy product (Auger et al., 2008; Maehle & Skjeret, 2022; Siró et al., 2008).

It is also unclear how consumers accept MA specifically as a meat alternative. Even though consumers claim to be more willing to eat MA as compared to insects and cultured meat (Grasso et al., 2019), consumers are generally hesitant to replace conventional meat with any alternative protein (Hartmann & Siegrist, 2017; Michel et al., 2021a; Onwezen et al., 2021). This is because consumers have a high attachment to meat (Graça et al., 2015) and also perceive meat to be more tasty, easier to prepare, more nutritious, cheaper, more natural, and sometimes even more environmentally friendly than meat substitutes (Michel et al., 2021).

5.1.2. Introducing novel MA-based food products

Despite the various acceptance barriers that MA may face, Asia could be a promising market for the introduction of novel MA-based food products. Because Asia is experiencing particularly extreme population growth and urbanization, the unique characteristics of MA cultivation, which include high yields, irrigation using seawater instead of freshwater, and the possibility of being carried out in urban spaces (e.g., on rooftops, in basements, and even in

consumers' own homes), would be especially beneficial in these countries. Furthermore, Asian consumers already have a high familiarity with and preference for (macro)algae and thus may be more open to adopting MA than consumers from other regions.

Among Asian countries, Singapore is a potential early adopter of MA-based products on a larger scale. As Singapore has very little agricultural land and, thus, relies heavily on imports, the country has been adopting innovative solutions to address this situation, for example, by being the first nation to approve the sale of cultured meat. As the wealthiest country in Asia, Singapore may consider investing in MA, as it is another novel technology that promises to increase their domestic food production. Often considered a model city "to be learned from and emulated worldwide" (Pow, 2014, p. 287), Singapore's innovative approaches to sustainable and urban food production may have a "trendsetting" influence on other cities, especially in Asia.

Even though Asia is a prospective market for alternative proteins such as MA, most of the previous research on consumers' acceptance of MA and alternative proteins was conducted with Western participants. Thus, the extent to which their results are generalizable to Asian consumers remains questionable. Firstly, there are large differences between Asian and Western diets, some of which are likely relevant to the acceptance of an MA meat substitute. In Asia, for example, vegetarianism is widespread and has religious significance, and seaweed is a dietary staple. As another example, typical Asian protein products and dishes (e.g., satay, sushi, tofu, or tempeh) differ from those eaten in the West (e.g., bacon, burgers, or sausages). Secondly, Asian and Western consumers have different food choice attitudes (Januszewska et al., 2011; Pearcey & Zhan, 2018; Prescott et al., 2002; Sproesser et al., 2018), which may impact their acceptance of novel foods (Bongoni, 2016; Bryant et al., 2019; Siegrist et al., 2015). Considering these large cultural differences, the existing body of knowledge provides few insights into the factors that facilitate the acceptance of MA-based food products in Asia.

Therefore, the current study investigates which attributes of a novel MA-based food product increase consumers' acceptance in Singapore. To this end, we examined the associations with the term "MA-based foods," perceptions of MA as compared to related food products (e.g., seaweed, meat products, and alternative proteins), perceptions of MA attributes (e.g., healthiness and environmental friendliness), the willingness to buy various MA-based foods products (e.g., noodles and burger patties), and the consumer characteristics associated with the willingness to buy MA-based foods.

5.2. Methods

5.2.1. Participants

Data were collected in 2022 through an online survey. Participants were recruited through the internet panel of DRB Research and received a small amount of compensation for their participation. We targeted consumers living in Singapore. Quotas were set for gender (50% female) and age (age range 20–79) to ensure that the study included the same number of participants in each age category.

The characteristics of the included 578 participants are displayed in Table 18. The sample was 48% female and had a mean age of 40 years. Educational level was measured and grouped into three categories: low (primary and secondary school or no education), coded as 1; medium (vocational school, high school), coded as 2; and high (applied university, university), coded as 3. Most participants had a high educational level (applied university, university). The sample's median yearly income was comparable to the national yearly income (Singapore Government Agency, 2022). Only 8% of participants lived alone; most of the sample either lived with a partner or with others. The ethnicity representation of the sample was comparable to the ethnicity representation of the Singaporean population (Singapore Government Agency, 2020), with about 71% being Chinese Singaporean and the remainder being Malay Singaporean, Indian Singaporean, or other nationalities. The sample ate meat, fish, and tofu multiple times a week, while meat and fish substitutes were only eaten a few times a month.

As can be seen in Table 18, about two-thirds of the sample were omnivores (n = 357), while one third of the sample (n = 231) indicated to reduce their meat consumption (i.e., they identified as flexitarian, pescetarian, vegetarian, or vegan). These participants were referred to as "meat reducers" during our data analysis. Among them, 18% reduced or excluded meat due to religious reasons. Throughout our data analysis, we chose to inspect this variable instead of "frequency of meat consumption," because the former explicitly refers to the intention to reduce meat, which should be highly relevant to the acceptance of MA-based meat substitutes. In comparison to the omnivores, the meat reducers did indeed eat less meat and fish and, instead, more tofu, meat substitutes, and fish substitutes. In comparison to the omnivores, meat reducers also had stronger sustainability and health concerns, as well as a lower meat attachment.

Table 18. Characteristics of the study sample (N = 578).

	Overall (N = 578)				Omnivore (n = 357)	Meat reducer (n = 231)	
	Possible range	M (SD) or %	item no.	Alpha[1]	M (SD)	M (SD)	t(577)
Demographic variables							
Age	20–79	39.80	1				
Women (%)		47.60	1				
Education (%)			1				
Low		1.20					
Middle		17.50					
High		81.30					
Income (%)			1				
Less than $20,000		15.20					
$20,000–$50,000		31.70					
$50,001–$100,000		31.20					
$100,001–$200,000		15.20					
More than $200,000		4.20					
Ethnicity (%)			1				
Chinese Singaporean		71.10					
Malay Singaporean		6.50					
Indian Singaporean		6.50					
Singaporean with other nationalities		6.80					
Other nationalities		9.10					
Diet							
Diet (%)			1				
Omnivore		59.90					
"Meat Reducer"[2]		40.10					
Flexitarian		24.50					
Pescetarian		6.30					
Vegetarian		7.70					
Vegan		1.60					
Reduction for religious reasons[3]		18.70					
Consumption frequency[4]							
Meat	1–7	4.47 (1.36)	1		**4.88 (1.17)**	3.92 (1.47)	8.72**
Fish	1–7	4.05 (1.28)	1		**4.19 (1.14)**	3.87 (1.47)	2.94*
Tofu	1–7	3.83 (1.22)	1		**3.71 (1.16)**	3.40 (1.57)	6.58**
Meat substitutes	1–7	2.87 (1.59)	1		2.54 (1.53)	**3.21 (1.69)**	5.80**
Fish substitutes	1–7	2.73 (1.61)	1		2.43 (1.51)	**4.04 (1.31)**	3.22*
Attitudes							
Sustainability concern	1–7	5.08 (1.08)	14	.95	5.02 (1.15)	**5.20 (1.00)**	2.80*
Health concern	1–7	4.23 (0.88)	8	.74	4.16 (0.91)	**4.37 (0.83)**	1.99*
Food neophobia	1–7	3.83 (0.75)	10	.69	3.79 (0.83)	3.89 (0.65)	1.49
Meat attachment	1–7	4.36 (0.89)	16	.86	**4.62 (0.80)**	3.97 (0.89)	9.18**
Social image eating motivation	1–7	4.55 (1.25)	3	.86	4.53 (1.26)	4.59 (1.24)	0.66

Note. [1]Cronbach's Alpha. [2]Non-omnivores were grouped as "meat reducers" during analysis. [3]Refers to the meat reducers who reduce meat consumption for religious reasons.[4]Answers were given from "Never" (1) to "Multiple times a day" (7). T-tests were conducted for omnivores vs. meat reducers: If significant, the greater value was marked in bold. * $p < .05$, ** $p < .001$.

5.2.2. Survey Questions

The survey was developed and distributed in English because it is the main language of Singapore. The survey took around 30 minutes to complete. The study was approved by the Eidgenössische Technische Hochschule (ETH) Zurich Ethics commission in Switzerland (2022-N-142) and the National University of Singapore (NUS) Institutional Review Board in Singapore (NUS-IRB-2022-525). The survey covered self-reported attitudes in relation to demographics, nutrition, and ecology. The correlations between the study variables are displayed in the Chapter Appendix in Table 22.

The *associations with the term "MA-based foods"* were assessed by asking participants "When you think of MA-based foods, what is the first association (word, image, or thought) that comes to mind?" Participants gave their answers as free text. They were then asked to rate each association on an 11-point scale from "Extremely negative" (-6) to "Neutral" (0) to "Extremely positive" (6).

The *food products associated with MA* were assessed by asking participants, "What is the first type of food product that comes to mind that would be suited to be MA-based?" Participants gave their answers as free text.

The *perception of food products* in a semantically differential format was assessed by asking the participants to rate seven food products—MA, beef burgers, chicken, tofu, plant-based burgers, seaweed, and insects—regarding nine adjective pairs on a 100-point scale (e.g., tasty (1) vs. disgusting (100)). The foods were chosen because they represent different types of meat and meat alternatives available to Singaporean consumers. For example, chicken is the most frequently consumed meat, whereas beef is one of the least frequently consumed meats in Singapore (Singapore Food Agency, 2021). Secondly, insects, tofu, and plant-based burgers can be used as meat alternatives. The first two are traditional foods, whereas plant-based burgers are modern. Lastly, seaweed was chosen because it is similar to MA.

The *perception of the attributes of MA-based foods* was measured by presenting participants with five attributes of MA-based foods (MA-based foods are environmentally friendly/healthy/high in protein/nutritious/innovative). Participants were asked, "These are attributes of MA-based foods. How convincing would these attributes be in terms of the purchase of MA-based food products?" Responses were given on a 7-point scale ranging from "Not convincing at all" (1) to "Extremely convincing" (7).

The *willingness to buy (WTB) MA-based food* was measured by presenting 16 foods that could be MA-based. For each food, participants were asked "Would you buy the following

food product if it was MA-based?" Responses were given on a 7-point scale ranging from "Definitely no" (1) to "Definitely yes" (7).

Concern about sustainability-related food issues (abbreviated "sustainability concern") was measured using 14 items (Grunert et al., 2014). Participants were asked, "How concerned are you with the following issues?" An example item was "The deforestation of the rainforest." Responses were given on a 7-point scale ranging from "Only slightly concerned" (1) to "Extremely concerned" (7).

Concern about health-related food issues (abbreviated "health concern") was measured using eight items taken from the general health interest subscale (Roininen et al., 1999). Participants were presented with eight statements, such as "I am very particular about the healthiness of food," and asked to indicate their level of agreement with each statement on a 7-point scale from "Strongly disagree" (1) to "Strongly agree" (7).

Food neophobia was measured with ten items (Pliner & Hobden, 1992). Participants were asked, "To what extent do you agree with the following statements?" An example item was "I am constantly sampling new and different foods." Responses were given on a 7-point scale ranging from "Strongly disagree" (1) to "Strongly agree" (7).

Meat attachment (Graça et al., 2015) was measured with 16 items. Participants were asked, "To what extent do you agree with the following statements?" An example item was "To eat meat is one of the good pleasures in life." Responses were given on a 7-point scale ranging from "Strongly disagree" (1) to "Strongly agree" (7).

The *diet* of participants was assessed by asking, "Which of these terms describes your diet best?" Response options were "Omnivore (My diet includes meat and fish)," "Flexitarian (I try to reduce my meat and fish consumption)," "Pescetarian (My diet excludes meat but not fish)," "Vegetarian (My diet excludes meat and fish)," and "Vegan (My diet excludes all animal products)." Participants who selected one of the last four options were categorized as "meat reducers" during the data analysis. The meat reducers were also asked, "Do you have a reduced meat and fish consumption out of religious reasons?" Response options were "Yes" or "No."

The *consumption frequency of meat, fish, and meat and fish substitutes* was measured for each of the four foods on a 7-point scale consisting of "Never" (1), "Rarely" (2), "1–3x per month" (3), "1–3x per week" (4), "4–6x per week" (5), "Daily" (6), and "Multiple times a day" (7).

Social image eating motivation was measured with three items that were a subscale of the Eating Motivation Survey (Renner et al., 2012). An example item was "I eat what I eat

because it is trendy." Responses were given on a 7-point scale ranging from "Strongly disagree" (1) to "Strongly agree" (7).

5.2.3. Data Analysis

All analyses were performed using SPSS Version 26 (SPSS Inc., Chicago, IL). A significance level of alpha = .05 was used. Pearson correlations were calculated between all study variables. We performed five main analyses: (I) The associations of MA-based foods were coded and categorized manually. Then, frequencies were assessed. A correspondence analysis (CA) was conducted for gender (male vs. female) and diet (omnivore vs. meat reducer) because men and women tend to have different associations with meat alternatives (Michel et al., 2021a). (II) We compared the perceptions of five MA-based food attributes using a within-subjects ANOVA. (III) To compare the perceptions of the seven food products regarding the nine adjective pairs, we split participants randomly into three groups to reduce the number of items shown to participants. Each group rated all seven products, but only did so regarding three adjective pairs. We conducted a within-subjects ANOVA, for which the adjective was the dependent variable (e.g., tasty) and the seven products were the independent variables. In Figure 19, the confidence intervals (CIs) are adjusted for within-subject effects according to Cousineau (2005). Thus, the non-overlapping 95% CIs indicate significant differences between one another. (IV) Participants' WTB for 15 MA-based food products was compared through a within-subjects ANOVA. The WTB for the 15 food products was analyzed via principal component analyses (PCAs). Two components had eigenvalues larger than 1 and explained 76% of the variance. We called Component 1 "(meat/fish) substitutes" (e.g., MA-based tuna, or burger patties) ($\alpha = .91$), and Component 2 "non-substitutes" (e.g., noodles, bread) ($\alpha = .95$). Their means were compared. (V) Linear regression analyses were conducted with the two variables previously obtained through PCA as dependent variables. Specifically, regression models were run predicting the WTB MA-based meat/fish substitutes (e.g., sushi containing MA-based fish, vegetarian burger patties) and MA-based non-substitutes (e.g., noodles, bread). The independent variables were gender, age, income, education, sustainability concerns, health concerns, food neophobia, being a meat reducer, and social image eating motivation.

5.3. Results

5.3.1. Associations with MA-based foods

Regarding the associations with the term "MA-based foods" (Table 19, section A), the most frequently mentioned categories were "vegetarian/vegan food" (e.g., plant-based food) (n = 48), "negative evaluation" (e.g., yuck or disgusting) (n = 38), and "positive evaluation" (e.g., good or awesome) (n = 35). The categories with the most positive affect were "vegetarian/vegan food" (M_{affect} = 2.36, SD_{affect} = 1.87), "health/nutrients" (M_{affect} = 1.79, SD_{affect} = 1.82), and "brands" (M_{affect} = 1.56, SD_{affect} = 1.76). The categories with the most negative affect were "negative evaluation" (M_{affect} = -2.34, SD_{affect} = 2.32), "bacteria" (M_{affect} = -1.92, SD_{affect} = 2.60), and "green color" (M_{affect} = -0.65, SD_{affect} = 2.08).

To reveal how certain consumer characteristics were related to the elicited associations, a CA is shown in Figure 18. Specifically, this figure illustrates the impact of participants' gender (male vs. female) and diet (omnivore vs. meat reducer) on the associations. Here, the associations (depicted as circles) placed closer to a group (depicted as squares) were mentioned more frequently by the respective group than the more distant associations. Only associations with n > 10 were included. The overall chi-squared value was $\chi^2(28) = 78.932$, $p < .001$, while the total inertia was $\lambda G = 0.24$. The first and second dimensions explain 43.9% and 36.9% of the inertia, respectively. Meat reducers—both male and female—named association categories with a positive affect more frequently as compared to other categories. Female meat reducers were more likely to name "health/nutrition" associations (e.g., protein-rich), whereas male meat reducers were likely to name a "positive evaluation" (e.g., "interesting"). Female omnivores were most likely to name associations with a negative affect, or a "negative evaluation" (e.g., "yuck") or "bacteria." Male omnivores had the most neutral associations in terms of affect because they were likely to name associations belonging to the "small," "sensory attributes," "green," and "seaweed" categories.

Considering the first type of food product that came to participants' minds in terms of being suited to containing MA (Table 19, section B), participants' associations appear to center on two food types: meat alternative products and vegetables/vegetable dishes, such as seaweed or salad. Other types of food, such as grains/cereals (e.g., bread, noodles), functional foods (e.g., supplements), milk and dairy products, snacks and sweets, and drinks were far less frequently named.

It is noteworthy that almost half of the participants gave no answers or nonsensical answers.

Table 19. (A) Associations with MA-based foods; (B) Products seen as suitable to be MA-based.

	Association/Answer		Affect	
	Frequency	%	*M*	*SD*
(A) Associations with the term "MA-based foods"				
Valid answers	355	100.00	0.16	2.14
1. Vegetarian food (e.g., plant-based food)	48	13.52	2.36	1.87
2. Negative evaluation (e.g., yuck, disgusting)	38	10.70	-2.34	2.32
3. Positive evaluation (e.g., good, awesome)	35	9.86	1.37	2.24
4. Health/nutrients (e.g., health, nutrient, protein)	29	8.17	1.79	1.82
5. Green color (e.g., green-colored food)	26	7.32	-0.65	2.08
6. Artificial (e.g., artificial food, man-made)	24	6.76	-0.21	1.61
7. Sensory attribute (e.g., gooey, salty)	24	6.76	-0.19	1.65
8. Seaweed (e.g., made from seaweed)	22	6.20	0.35	1.43
9. Plants (e.g., plants, ferns, plant-based)	20	5.63	0.05	1.47
10. Brands (e.g., McDonalds, Impossible burger)	16	4.51	1.56	1.76
11. Small (e.g., small portion, non-noticeable)	13	3.66	-0.46	1.81
12. Bacteria (e.g., based on bacteria, germs)	13	3.66	-1.92	2.60
13. Vegetables (e.g., vegetables, broccoli)	12	3.38	1.25	1.60
14. Meat (e.g., meat, chicken, beef)	10	2.82	0.70	1.70
15. Organic (e.g., organic, organic food)	8	2.25	0.75	1.91
16. Biological concept (e.g., microorganism)	7	1.97	-0.29	2.81
17. Aquatic environment (e.g., sea, underwater)	6	1.69	0.17	2.4
18. Seafood (e.g., seafood, tuna, salmon)	4	1.13	1.50	2.38
Invalid answers: no answers or nonsensical answers	223	---	---	---
(B) Food products seen as suitable to be MA-based				
Valid answers	346	100.00		
1. Meat (alternative) product (e.g., patty, sausage)	96	27.75		
2. Seaweed product (e.g., wakame, seaweed salad)	54	15.61		
3. Vegetables (e.g., salad, vegetables)	44	12.72		
4. Milk and dairy product (e.g., yogurt, milk)	33	9.54		
5. Vegetarian/ vegan product (e.g., plant-based food)	25	7.23		
6. Fish/seafood (e.g., sea cucumber, fish)	19	5.49		
7. Grains/cereals (e.g., bread, noodle, rice)	13	3.76		
8. Supplement (e.g., vitamins, spirulina)	13	3.76		
9. Soybean product (e.g., soybean, tofu, bean curd)	13	3.76		
10. Snacks and sweets (e.g., chips, cookies)	12	3.47		
11. Fruit product (e.g., juice, jam)	10	2.89		
12. Drinks (e.g., smoothie, Yakult)	8	2.31		
13. Animal feed (e.g., fish food, feed)	6	1.73		
Invalid answers: no answers or nonsensical answers	232	---		

Note. Percentages are based on the number of "valid answers." Affect was measured on a scale from "Extremely negative" (-6) to "Neutral" (0) to "Extremely positive" (6). Affect was only assessed for section A.

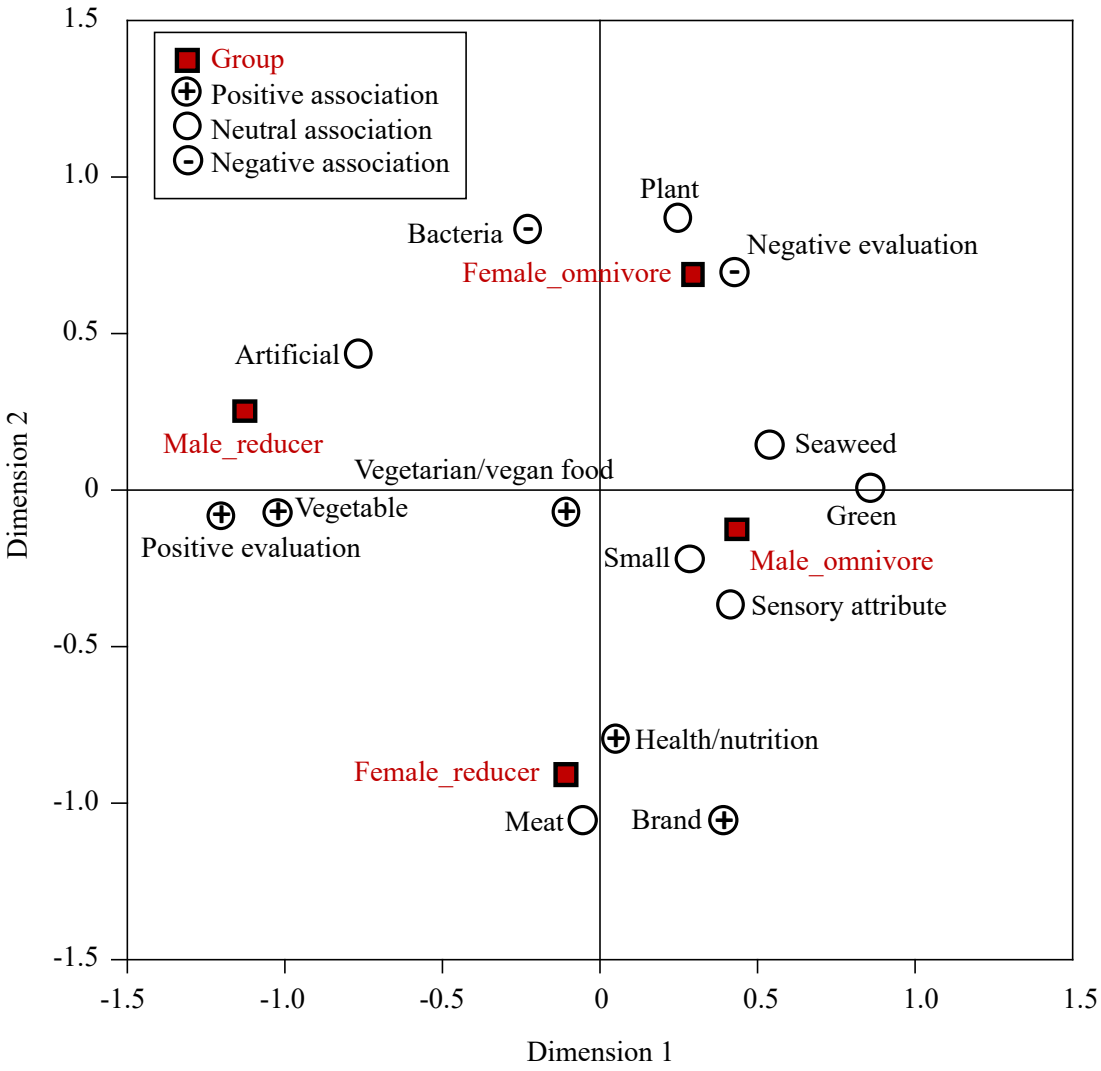

Figure 18. Correspondence analysis of the associations with the term "MA-based foods." Associations are shown in relation to gender (male vs. female) and diet (omnivore vs. meat reducer). Association affects are according to Table 19 (Positive: M_{affect} above 1; Neutral: M_{affect} between -1 and 1; Negative: M_{affect} below -1).

5.3.2. Perception of MA in comparison to other foods

Figure 19 shows consumers' rating of seven food products regarding nine adjective pairs. The ANOVA showed that, within each adjective pair (e.g., tasty vs. disgusting), the products' ratings were different on an overall level. Only the adjective pair "rich in protein vs. low in protein" was an exception to this (i.e., all products were perceived to have the same protein content).

The overall most favorably perceived foods were tofu and seaweed. Overall, they had the highest scores in terms of being perceived as tasty, festive, natural, healthy, and cheap.

Chicken had comparable scores regarding these adjectives, except that it was perceived as less environmentally friendly and more expensive than tofu and seaweed. In comparison, beef burgers were perceived far more negatively. Beef burgers were perceived as less tasty, less festive, less natural, less environmentally friendly, less healthy, and more expensive than tofu and seaweed. Insects were the least favorably perceived food, as they were rated the most disgusting, primitive, environmentally unfriendly, unhealthy, and low-protein food.

Consumers' perceptions of MA were most similar to their perceptions of plant-based burgers. Specifically, both these foods received comparable ratings for all adjectives, except for the adjectives "cheap vs. expensive," for which plant-based burgers were rated as more expensive than MA. Both were seen as the most modern of the presented foods. Consumers appear to be somewhat aware of the environmental benefits of these two products, as they were rated as more environmentally friendly than beef burgers and chicken. However, consumers appear to be unaware of the potential nutritional benefits of these foods, as they received similar scores to most of the other foods in terms of healthiness and protein content. At the same time, consumers perceived MA and plant-based burgers to be less festive, natural, and cheap than seaweed, tofu, and chicken.

5.3.3. Perception of MA-based foods' attributes

As depicted in Figure 20, consumers were presented various attributes of MA-based foods and were asked how convincing these were in terms of the purchase of MA-based foods. The within-subject ANOVA showed an overall difference between the means, $F(3.673, 2119.226) = 555.73$, $p < .001$. Furthermore, all pairwise differences were significant. All these differed at an alpha level of $p < .001$, except for the means of "environmentally friendly" vs. "healthy" ($p < .05$). Innovative was rated as the most convincing attribute. Environmental friendliness ranked in second place in this regard, and the healthiness of MA-based foods ranked third. The attributes related to nutrition (i.e., the nutrient richness and the high protein content of MA-based foods) were ranked fourth and fifth, respectively.

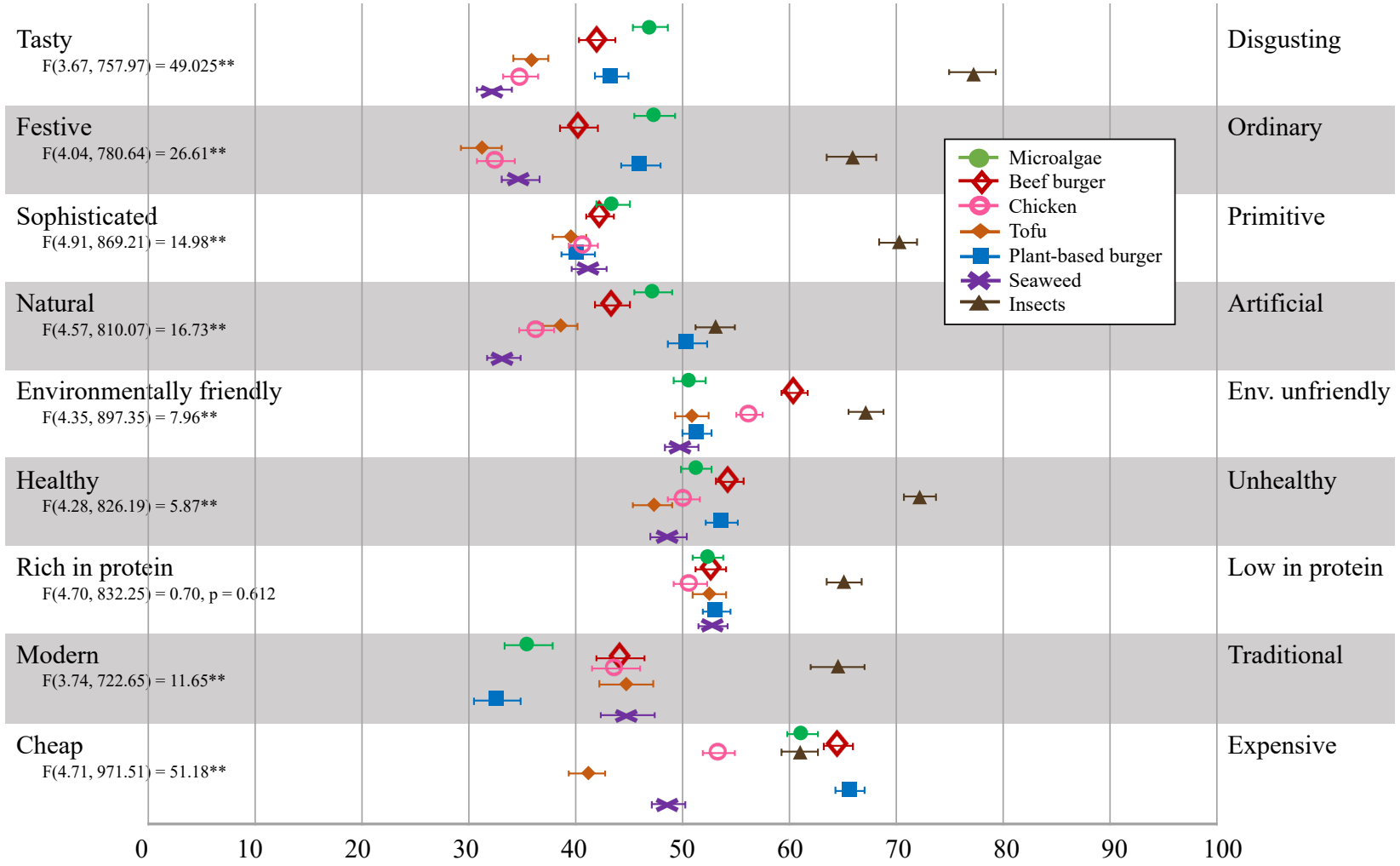

Figure 19. Perception of various food products. Means and 95% CIs (adjusted for within-subject effects) are shown. Non-overlapping CIs between means indicate significant pairwise differences. ** indicates overall difference ($p < .001$) between the seven foods.

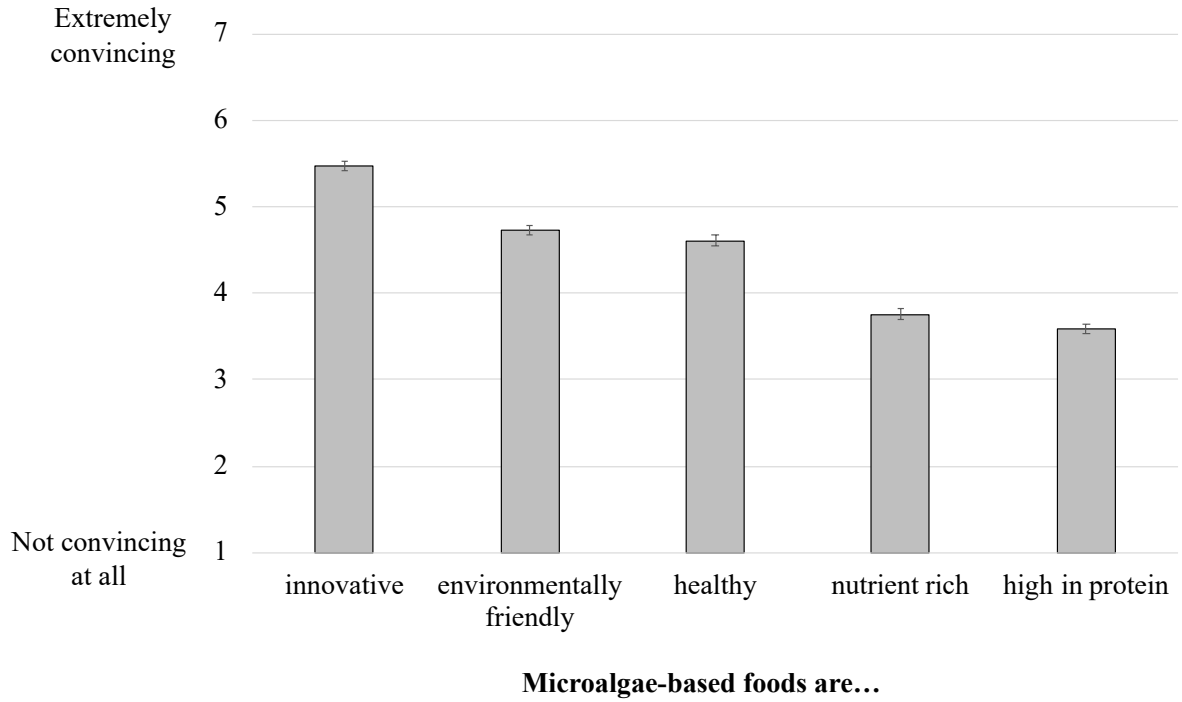

Figure 20. Perception of the attributes of MA-based foods. Participants were asked "How convincing would these attributes be for the purchase of MA-based foods?" *M* (*SE*) are shown. All means differ significantly from one another.

5.3.4. The WTB MA-based foods

As depicted in Table 20, the WTB the 15 products differed significantly, $F(8.254, 3301.620) = 5.084$, $p < .001$. Consumers' WTB was higher for "non-substitutes" (e.g., noodles, bread) than for "substitutes" (e.g., sushi containing MA-based fish, MA-based sausages). However, when we compared all 15 products, we found large WTB differences within the "substitutes" category. When substitutes were presented in a dish—i.e., sushi and satay—they received ratings similar to those of non-substitutes. In other words, participants were just as willing to buy MA-based sushi and satay as they were willing to buy MA-based noodles, bread, and other non-substitutes. In contrast, the substitutes "on their own" (i.e., MA-based burger patties, tuna, fish balls, sausages, and abalone) received lower ratings than all other foods.

5.3.5. Consumer characteristics predicting the WTB MA-based foods

To understand the consumer characteristics predicting the WTB of these two food categories, two linear regression models were conducted, with the two categories as dependent variables (Table 21). Both models were significant and indicated that sustainability concern

was the strongest predictor of WTB. In both models, consumers with a high WTB MA-based food products were more likely to be male, younger in age, have a high income, strong sustainability concerns, strong health concerns, a low food neophobia, strong social image eating motivations, and more likely to be meat reducers as compared to being an omnivore.

Table 20. Willingness to buy (WTB) 15 MA-based food products.

	M (*SD*)	Alpha[a]
Product categories		
Substitutes [S]: includes 7 products	4.28 (1.46)	.91
Non-substitutes [NS]: includes 8 products	4.41 (1.49)	.95
S vs. NS: $t(577) = 3.112$, $p = .002$		
Products (in descending order)		
1. Noodles [NS]	4.57 (1.51)[10, 11, 12, 13, 14, 15]	
2. Bread [NS]	4.50 (1.58) [14, 15]	
3. Sushi (with MA-based fish substitute) [S]	4.47 (1.70) [12, 13, 14, 15]	
4. Steamed bun [NS]	4.43 (1.57)	
5. Crackers [NS]	4.42 (1.65)	
6. Chips [NS]	4.41 (1.62)	
7. Protein bar [NS]	4.38 (1.71)	
8. Supplement powder [NS]	4.36 (1.61)	
9. Satay (with MA-based meat substitute) [S]	4.35 (1.65)	
10. Cookies [NS]	4.35 (1.61)[1]	
11. Vegetarian burger patty [S]	4.30 (1.65) [1]	
12. Vegetarian tuna [S]	4.22 (1.72) [1, 3]	
13. Vegetarian fish balls [S]	4.22 (1.64) [1, 3]	
14. Vegetarian sausages [S]	4.22 (1.65) [1, 2, 3]	
15. Vegetarian abalone [S]	4.16 (1.70) [1, 2, 3]	

Note. Participants were asked "Would you buy the following food product if it was MA-based?" Answers were given from "Definitely no" (1) to "Definitely yes" (7). The two product categories were obtained through a varimax-rotated PCA. Subscript numbers indicate the products for which there were significant differences, according to Bonferroni-corrected post hoc tests: [a]Cronbach's Alpha.

Table 21. Linear regression predicting the WTB MA-based foods.

	Meat/fish substitutes (e.g., sushi containing MA-fish, sausages)			Non-substitutes (e.g., noodles, bread)		
	B	95% CI	β	*B*	95% CI	β
Constant	1.98	[0.81, 3.33]		2.46	[1.53, 3.96]	
Gender (0 = m, 1 = f)	-0.24	[-0.44, 0.03]	-0.08*	-0.16	[-0.34, 0.08]	-0.05
Age	-0.01	[-0.02, 0.05]	-0.12*	-0.01	[-0.02, 0.01]	-0.09*
Income	0.14	[0.04, 0.24]	0.10*	0.22	[0.02, 0.24]	0.17**
Education	-0.18	[-0.43, 0.07]	-0.05	-0.13	[-0.36, 0.11]	-0.04
Sustainability concern	0.33	[0.23, 0.44]	0.25**	0.27	[0.18, 0.37]	0.22**
Health concern	0.19	[0.06, 0.31]	0.11*	0.18	[0.06, 0.30]	0.11*
Food neophobia	-0.30	[-0.4, -0.15]	-0.15**	-0.37	[-0.50, -0.23]	-0.20**
Meat reducer (0 = no, 1 = yes)	0.54	[0.33, 0.75]	0.80**	0.45	[0.25, 0.66]	0.16**
Social image eating motivation	0.20	[0.12, 0.29]	0.18**	0.14	[0.06, 0.23]	0.13*
	$R^2 = .28$, $F(9, 554) = 24.402$, $p < .001$**			$R^2 = .27$, $F(9, 554) = 22.18$, $p < .001$**		

Note. * $p < .05$; ** $p < .001$.

5.4. Discussion

Even though MA are a nutritious and sustainable protein source, little is known about their acceptance by consumers. Thus, the current study investigates the attributes of MA-based food products that could increase acceptance in a Singaporean sample. In terms of product category, an MA-based meat substitute may be accepted by Singaporean consumers because the most common association with "MA-based foods" was "meat substitutes". Furthermore, meat reducers, as compared to omnivores, had more positive attitudes toward MA-based foods. To increase acceptance, an MA product's framing should (A) associate the product with traditional Asian cuisine because our participants viewed seaweed and tofu (two traditionally Asian foods) more positively than beef burgers and plant-based burgers (two product carriers originating from Western cuisine) in terms of taste, naturalness, and price; (B) emphasize that the product is "innovative" and "sustainable" because these were the two most convincing attributes in terms of purchasing an MA product—accordingly, sustainability concern and social image eating concern were positively associated with the WTB MA-based foods; and (C) emphasize the product's health benefits—these were more convincing for consumers than the product's high protein or nutrient content.

5.4.1. An MA-based meat/fish alternative product may be accepted by consumers

Our results suggest that an MA-based meat/fish alternative product may be positively received by Singaporean consumers. We conclude this based on the finding that vegetarian/vegan products (named 48 times) and meat alternative products (named 94 times) were the products most often associated with MA. They were named more often than dairy products (named 33 times) or grains/cereals (named 13 times), for example. In line with this, meat reducers, as compared to omnivores, had more positive associations with and a higher WTB MA-based foods, suggesting that they may be ideal target consumers. Furthermore, participants already displayed a positive perception of tofu and seaweed, two foods that can also be used as protein alternatives to meat. Specifically, tofu and seaweed were rated as more tasty, festive, natural, environmentally friendly, healthy, and cheap than beef. Thus, it can be assumed that Singaporean consumers may also have positive perceptions of new alternative protein products based on MA.

Our conclusion that an MA-based meat/fish substitute product could be positively received by Singaporeans is also supported by the cultural significance of vegetarian practices in Asia. There, vegetarianism or at least the avoidance of certain meats has been practiced for

hundreds of years in Buddhist cultures (e.g., China, Singapore, and Vietnam), Muslim cultures (e.g., Malaysia and Indonesia), and Hinduist India, which has the world's largest population of vegetarians (Statista, 2021). As a result, plant-based protein products (e.g., tofu, tempeh, and soymilk) are culinary staples in Asian cuisine. Because familiarity with vegetarian eating patterns and products are an important determinant of consumers' acceptance of meat substitutes (Hoek et al., 2011; Schösler et al., 2012), a new MA-based plant-based product could have economic potential in Asian markets.

What may go against our conclusion is the finding that consumers were more willing to buy MA-based products in the "non-substitutes" category (e.g., noodles, bread) as compared to products in the "substitutes" category (e.g., sushi containing MA-based fish, vegetarian sausages). However, there were difference depending on the framing of the meat/fish substitute. Specifically, meat/fish substitutes presented as part of a dish (sushi and satay) received ratings just as high as non-substitutes such as noodles, bread, or crackers. In contrast, the substitutes "on their own"—MA-based burger patties, tuna, fish balls, sausages, and abalone—received lower ratings than all the other foods.

Because sushi and satay are well-known dishes in Asia, our results confirm that using familiar preparations can increase the liking of and willingness to eat novel foods (Pelchat & Pliner, 1995, Tuorila et al., 1998, Wansink, 2002). Using more recent research with insects to illustrate this, Tan, Van den Berg, and Stieger (2016) showed that presenting insects within familiar foods and dishes (e.g., in a beef stew, curry, or a brownie) improved consumer acceptance. However, simply presenting insects in well-known or well-liked preparations was not enough to maximize acceptance (Tan et al., 2016). For instance, while grasshoppers were perceived as appropriately flavored with chili and salt, they were perceived as inappropriately flavored with chocolate (Tan et al., 2015), indicating that consumers expectations also play a role in acceptance. Thus, while familiarity with and preference for a carrier product is important, additional factors (e.g., perceived appropriateness) influence the ideal carrier "match" for a novel MA-based product.

5.4.2. Associating the product with traditional Asian cuisine may increase acceptance

Our findings suggest that associating an MA-based product with traditional Asian, rather than Western cuisine, may increase Singaporean consumers' acceptance. We conclude this because beef burgers and plant-based burgers—both typically Western meat products—were viewed as less tasty, natural, and cheap than "traditional" Asian foods, such as seaweed and tofu. Both seaweed and tofu were seen very positively, even in comparison to chicken.

Furthermore, participants were more willing to buy MA-based meat/fish analogues when they were prepared in traditionally Asian dishes, such as sushi or satay, as compared to the substitutes "on their own."

Our results demonstrate the importance of considering cultural preferences when developing an alternative protein product. Western consumers prefer typically Western products, such as burgers, steak, sausages, or chicken nuggets, over non-Western proteins, such as tofu and algae (Michel et al., 2021a; Michel et al., 2021). In our Asian sample, the opposite preference was observable. This may be because modern Asian diets are still heavily influenced by traditional cuisine (Cai & Situ, 2006; Zhang et al., 2009). Thus, consumers prefer traditional foods to Western foods (Chang et al., 2010; Wang et al., 2016). To achieve an association with traditional cuisine, the packaging of an MA-product may show it prepared like tofu; the product type could be typically Asian (e.g., fish balls or satay chunks); or the brand name could contain elements of an Asian language (e.g., "Z-Rou," a real-life plant-based company name that plays with the Chinese word for meat, "Ròu"). In turn, a framing that evokes Western food should be avoided. For example, it is questionable to what extent Asians will be drawn to certain product categories (e.g., bacon, hotdogs, or meatballs) and brand names such as "Tofurkey" or "Field Roast," both of which are the names of real-life plant-based companies (that evoke the American Thanksgiving turkey and the traditional Christmas beef roast). Ye et al. (2022) demonstrated how product names can be used to influence consumer perceptions. They found that showing Chinese participants an alternative protein with the label "vegetarian meat," as compared to "plant-based meat" or "artificial meat," led to more positive attitudes, as it reminded participants of traditional and familiar Chinese vegetarian dishes and led to fewer taste concerns. Thus, Asian consumers' preferences regarding a meat alternative name largely differ from those of Western consumers.

5.4.3. Framing the product as sustainable, innovative, and trendy may increase acceptance

The two most convincing attributes of MA were that they were "innovative" and "environmentally friendly." Accordingly, we found that the WTB MA was strongly predicted by environmental concern and social image eating motivations (i.e., the motivation to eat foods because they are "trendy" and make consumers "look good in front of others"). Interestingly, the regression analysis showed that the effect of these two attitudes was similarly large to that of food neophobia on the willingness to buy MA.

These findings suggest that the framing of an MA-based product should appeal to collectivist cultural values held in Asia. Food choices in Asian cultures, which can generally be characterized as collectivistic cultures, tend to have a strong relationship to society (e.g., societal benefits, social standing, and social norms), at least in comparison to Western cultures, where food choices relate more strongly to individual wants (Markus & Kitayama, 1991; Rahman & Luomala, 2021; Yoon et al., 2011). Thus, it is understandable that Asians would claim that the environmental friendliness of food, which creates societal benefits, is important to them (Cho et al., 2013; Hofstede & Hofstede, 2001). Consumer acceptance may be further enhanced if, in addition to environmental friendliness, an MA-based product also claims to be organic and locally produced (Weinrich & Elshiewy, 2019).

Collectivistic values may also impact Asian consumers' willingness to adopt novel foods if these are perceived as symbols of social status. For example, Asian countries tend to have a higher acceptance of cultured meat than many Western countries (Bryant et al., 2019; Siegrist & Hartmann, 2020b). This was also reported in a study by Chong, Leung, and Lua (2022), which found that the willingness to buy cultured meat was higher in Singaporean participants than American participants. Interestingly, this difference was explained by Singaporean participants' higher social image eating motivations. "It is likely that the Singaporean cultural trait of *kiasuism*, which is exemplified by the fear of losing out or being left behind, motivates Singaporeans to project an image of being 'ahead of the curve' (…) by being more receptive to novel foods such as lab-grown meat" (Chong et al., 2022, p. 5). On a national level, this mindset may have manifested in Singapore's decision to be the first country to approve cultured meat sales. On an individual level, a Singaporean consumer may seek to buy novel foods to project a positive social image. Our findings seem to confirm that the opinions of others have a significant impact on the acceptance of MA-based foods (Maehle & Skjeret, 2022).

Our findings indicate that Asian consumers may view the novelty of meat alternatives positively. Specifically, it was found that the term "plant-based meat alternatives" elicited positive associations, such as "innovation," "trendiness," and "high-tech," among Chinese consumers (Cho et al., 2013). Indeed, it appears that Asian consumers are more open to food innovations than Western consumers (Bongoni, 2016; Bryant et al., 2019; Losada-Lopez et al., 2021; Rabadán & Bernabéu, 2021; Siegrist et al., 2015), which could be explained by differences in food-related concerns. Specifically, while food naturalness is a dominant concern in the West (Roman et al., 2017), food hygiene and safety concerns are prioritized in the East (Siegrist et al., 2020). Therefore, while Western consumers may dislike novel foods

due to their bias against unnatural and processed foods (Hoek et al., 2011; Siegrist & Sütterlin, 2017), this effect may be less pronounced for Asian consumers (Siegrist & Hartmann, 2020b), who appear to associate food novelty and processing with food safety (Dempsey & Bryant, 2020; Inbalakshmi et al., 2014; Sabri et al., 2013).

Overall, the positive effect of collectivistic food choice attitudes (e.g., the motivation to eat foods that have societal benefits or boost social image) could act against the negative effects of food neophobia on the acceptance of novel foods. Our results suggest that the reluctance to eat unfamiliar foods (i.e., food neophobia) affects food choice in Asian countries. Indeed, food neophobia is a culturally universal trait that will always be one of the main barriers to more sustainable consumption patterns (Siddiqui et al., 2022). However, Singaporean consumers' environmental concerns and motivation to eat foods that boost their social image may help them overcome this inherent reluctance to try novel products. Exploiting these attitudes (e.g., during the design or marketing of a new product) to attract consumers to alternative proteins will be vital.

5.4.4. Emphasizing the products' health benefits may increase acceptance

We found that some of the most common associations with MA-based foods were related to healthiness. Furthermore, the health benefits of MA were similarly as convincing as the sustainability benefits of MA. Accordingly, consumers with a high level of health concern had a higher willingness to buy MA-based food. In this regard, gender may be relevant in that female meat reducers, as compared to male meat reducers, associated MA-based foods with health/nutrition benefits more often. It is noteworthy that the holistic healthiness of MA ("MA are healthy") was rated as more convincing than the nutritional aspects of MA ("MA are high in nutrients/protein") in terms of purchasing MA.

Based on these findings, we conclude that emphasizing the health benefits of MA-based foods may increase acceptance. Indeed, Asians strongly believe in the connection between diet and health. The concept of functional foods originated in Japan, where FOSHU-labelled foods (*FO*od for *S*pecified *H*ealth *U*ses) are largely popular (Kwak & Jukes, 2001). In China, the tradition of nutritional medicine is still widespread (Anderson, 1988). This mindset was reflected in a study by Siegrist et al. (2015), which found that Chinese consumers were more willing to buy a food product when it was described as having "additional health benefits" as compared to when it was described as not having any such benefits. Interestingly, the effect was reversed for German consumers. For them, many functional benefits reduced their willingness to buy the product.

Our results also suggest that consumers may prefer holistic health claims ("this product is healthy") over more specific functional or health claims (i.e., "this product is high in nutrients/protein"; Siró et al., 2008). As Siro et al. (2008, p. 462) point out, it "may seem paradoxical that the more 'evidence-based' a functional claim is, the less likely it is to appeal to the consumer market." However, research suggests that consumers do not generally have the necessary background knowledge to evaluate specific functional claims and relate them to their personal health (Bech-Larsen & Scholderer, 2007; Verbeke, 2006).

5.4.5. Limitations

We acknowledge the various limitations of our study. Firstly, in response to the association tasks, half of the participants gave no answers or nonsensical answers. This indicates that many participants were unfamiliar with MA, limiting the usefulness of our results. Secondly, Asian survey respondents tend to avoid extreme response styles, favoring the middle of Likert-style scales (Peterson et al., 2014). This is noteworthy because the interpretation of our results included many comparisons to Western consumers' perceptions. Lastly, it is unclear how our findings apply to other Asian markets given that diets across Asia are heterogenous due to cultural and socioeconomic factors. In terms of culture, our findings are perhaps most generalizable to China and countries with a Chinese cultural influence (e.g., Japan and Korea) because the majority of our participants were Chinese Singaporean. In terms of socioeconomic factors, it is unlikely that less developed Asian countries (e.g., Malaysia and Indonesia) will have the same dietary needs and preferences as Singapore.

5.4.6. Conclusion

Because MA are a promising future protein source, it is important to understand consumers' acceptance of novel MA-based food products. The current study identified which attributes of an MA-based food product increase acceptance in Singapore. Ideally, an MA-based food product should be a meat/fish substitute; be aligned with traditional Asian cuisine; be framed as environmentally friendly, innovative, and trendy; and have an emphasis on health benefits. Building on these findings, the next variables to be examined should refine potentially successful product concepts (e.g., identifying the ideal carrier product, flavoring, marketing strategy, and willingness to pay) and analyze consumers' sensory perceptions of MA. Because Singapore is often considered a "trailblazer" to be learned from and emulated, the potential success of novel MA-based food products in Singapore could pave the way for MA cultivation in other countries, especially in Asia.

At a broader level, this study highlights that consumer demands, preferences, and needs are not one-size-fits-all but, rather, vary between cultures and countries. In general, most studies on human behavior have been conducted with participants from WEIRD (Western, educated, industrialized, rich, and democratic) countries, even though these countries only house about one-tenth of the global population (Henrich et al., 2010). Because their findings may not be internationally generalizable, our understanding about human behavior in non-WEIRD societies is limited. This general problem of psychology also prevails in the study of the consumer acceptance of novel foods (Siegrist & Hartmann, 2020a). For example, many alternative research activities (Hartmann & Siegrist, 2017; Onwezen et al., 2021) and protein companies (e.g., Beyond Meat) have been based in Europe and North America. As a result, we have little insight into how to promote eco-friendly diets in the rest of the world, for example, in Asia. However, in comparison to other continents, Asia has not only the largest protein demand and market, but also the largest number of developing countries, which are the most in need of the potential food aid and climate change alleviation novel technologies may help with. Therefore, it is important that consumers of all backgrounds are considered when sustainable behavior is promoted.

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Chapter Appendix

Table 22. Inter-correlations among study variables.

		1	2	3	4	5	6	7	8	9	10
1	Gender (0 = m, 1 = f)		-.17**	-.02	-.12*	-.02	.02	.03	-.06	-.02	-.05
2	Age			-.21**	< .01	.02	.13*	.10*	-.12*	< .01	-.07
3	Education				.23**	-.03	-.01	-.05	.08*	-.02	.03
4	Income					< .01	.01	-.12*	-.05	.10*	.17**
5	Sustainability concern						.25**	-.12*	-.02	.08*	.31**
6	Health concern							-.14**	-.26**	.12*	.13*
7	Food neophobia								-.10*	.06	-.14*
8	Meat attachment									-.36**	-.10*
9	Meat reducer (0 = no, 1 = yes)										.15**
10	(Positive) affect of association with MA-based foods										

Note. * $p < .05$. ** $p < .001$.

Chapter 6

General Discussion

Food systems must be transformed to restore planetary health and secure a continued food supply. Consumers are central to this transformation, as they can improve their consumption habits and simultaneously drive the demand for sustainable food production. To support consumers' behavioral transitions, the current dissertation addresses gaps in our understanding of environmentally friendly food choice behavior. Specifically, it encompasses four studies regarding factors that impact consumers' selection of environmentally friendly meals, eco-labels, and alternative proteins.

Since meals are fundamental to our daily eating routines, the way we compose them greatly impacts our environmental footprint. To elaborate on how we can shift toward more environmentally friendly meal composition habits, Chapter 2 analyzed how and why Swiss consumers choose foods when they are prompted to compose an environmentally friendly meal from a fake food buffet. It revealed the misconceptions and (taste- and neophobia-related) biases that need to be resolved in order for a shift toward more sustainable consumption habits to occur.

Countless types of processed food products contain unsustainable ingredients such as palm oil. Thus, consumers' use of eco-labels can substantially lower the environmental footprint of their grocery purchases. To understand the factors that may affect this, Chapter 3 presented an online study that investigated Swiss consumers' concern and awareness of palm oil and the RSPO label. It demonstrated that eco-labels are only effective if certain pre-requisites on consumer side (e.g., label familiarity) are met.

Shifting our reliance from meat to alternative proteins can greatly reduce the impact of our food system on the planet. To understand why insects remain a taboo food in the Western world, Chapter 4 presented a meta-analysis on the correlates of the WTC insects reported in past literature. It revealed that, across a large number of studies, variables related to disgust and neophobia were found to have the most impact on societies' perception of insects as food. It is thus unlikely that entomophagy will become a globally accepted practice anytime soon.

As a variety of novel alternative protein technologies continue to emerge, it is up to consumers to adopt them into their diets. To identify the factors that may facilitate this in the case of MA, the online study presented in Chapter 5 identified the attributes of a novel MA-based product that may increase acceptance in a Singaporean sample of consumers. The study demonstrated the need for tailoring novel products to culture-specific preferences to elicit a more widespread adoption of sustainable new technologies.

The following section separately discusses the central findings of each of these studies (see Table 23), while providing suggestions for future research. Subsequently, implications for actors in the food system (e.g., consumers, industry, and policymakers) are pointed out, and the limitations of the studies are addressed. The dissertation closes with a conclusion.

Table 23. Overview of this dissertation's central findings.

Topic	Research question	Central findings
Topic 1: **Environmentally friendly meals**	What are consumers' approaches to composing an environmentally friendly meal?	1. Suppression of "default" hedonistic food choices 2. Selection of less meat and fish (in particular, steak) 3. Selection of more meat substitutes (in particular, falafel) 4. Selection of regional, seasonal, and organic foods
Topic 2: **Palm oil and the RSPO label**	How aware and concerned are consumers about palm oil and the RSPO label?	Although consumers are highly concerned about palm oil, they are unaware of which products contain it, and unfamiliar with the RSPO label. Consequently, it is unlikely that consumers can make more sustainable palm oil-based purchases, even if they wanted to do so.
Topic 3: **Insects as food**	What factors reportedly correlate with consumers' WTC insects?	1. Affect-based factors ($\bar{r}$ = -.33–.55, k = 16–20) 2. Information-based factors ($\bar{r}$ = .32–.55, k = 4–5) 3. Familiarity-based factors ($\bar{r}$ = .10–.35, k = 3–14) 4. Curiosity-based factors ($\bar{r}$ = .29, k = 6) 5. Sociodemographic variables ($\bar{r}$ = -.14–.00, k = 13–20)
Topic 4: **Microalgae**	What product attributes increase consumers' acceptance of novel MA-based foods?	1. Product type: meat or fish substitute 2. Compatibility with local, traditional cuisine 3. Framing as innovative, trendy, and sustainable 4. Emphasis of health benefits

Note. Statistical notations refer to meta-analytic variables: $\bar{r}$ is the mean effect size, and k is the number of studies that have contributed to this effect size.

6.1. Central findings

6.1.1. Topic 1: Consumers' approaches to composing an environmentally friendly meal

Meals are the building blocks of our daily diet, as most of what we eat throughout the day comes from breakfast, lunch, and dinner meals. Therefore, transforming how we fundamentally compose our meals can positively impact our environmental footprint. To elaborate on the patterns of this shift, Chapter 2 analyzed how and why Swiss consumers chose foods when they were asked to compose either a meal entirely to their liking (control group) or an environmentally friendly meal (eco group) from a fake food buffet while "thinking aloud." The focus was on assessing potential heuristics (i.e., "rules of thumb") to identify environmentally friendly foods. The control groups' behavior was interpreted to represent the public's "default" or "normal" meal composition tendencies.

First, consumers trying to compose an environmentally friendly meal appeared to suppress their "default" food choice heuristic, which was to choose foods they perceived as tasty. The control group chose foods most frequently based on perceived tastiness; at least one-third of the foods in their meal were chosen for this reason. In comparison, the eco group mentioned taste and visual appeal far less often. These results suggest that taste and visual appeal are a humans' dominant food selection heuristics (Scheibehenne et al., 2007).

Second, consumers trying to compose an environmentally friendly meal selected less meat and fish than they normally would have. Specifically, the eco group selected less steak and salmon than the control group, which significantly lowered the eco-points of their meals. However, the meals of both groups did not differ in terms of other animal-based foods (i.e., chicken, lamb, cheese, egg, and desserts). This implies that when consumers are prompted to compose a more environmentally friendly meal, they will still select many animal-based foods that have an underestimated environmental impact, such as chicken and cheese (Hartmann et al., 2022). Some of these foods, especially dairy, constitute a large part of Western diets (see Figure 2).

Third, consumers trying to compose an environmentally friendly meal selected more meat substitutes than they normally would have. Specifically, the eco group selected more falafel than the control group. However, the other meat substitutes presented in the buffet (i.e., plant-based "chicken," Beyond Meat Burger, Quorn fillet, and Quorn nuggets) were selected in equal amounts by both groups. Furthermore, both groups selected equal amounts of vegetables, fruits, and grains. This implies that when consumers are prompted to compose an

environmentally friendly meal, they are unwilling to select higher amounts of novel meat alternatives (e.g., Beyond Meat Burger), vegetables, fruits, and grains than they normally would. It is unfortunate that consumers find particularly the protein-rich plant-based foods (e.g., legumes, or novel alternative proteins) unappealing (because of taste, for instance) (Henn et al., 2022; Michel et al., 2021), as these can be nutritiously superior replacements for animal protein (Farsi et al., 2022).

Fourth, consumers trying to compose an environmentally friendly meal selected more regional, organic, and local foods than they normally would have. Hereby, "regionality" was the most important heuristic cue for selecting environmentally friendly foods, since at least one-third of the eco group's meals were composed using this criterion. This is in line with past studies that showed that consumers associate these three attributes with food environmental friendliness (Bosona & Gebresenbet, 2018; Lazzarini et al., 2017; Lazzarini et al., 2016; Tobler et al., 2011; Wallnoefer et al., 2021), even though the reported correlation between these attributes and environmental impacts varies greatly between studies (Macdiarmid, 2014; Nemecek et al., 2016).

In summary, consumers' approaches to composing an environmentally friendly meal were suboptimal. Consumers were aware that decreasing their meat and fish intake (specifically, steak and salmon) in favor of plant-based meat substitutes (specifically, falafel) could improve the environmental friendliness of their diet. However, consumers could have further improved their behaviors by (1) minimizing their intake of meat, fish, eggs, and dairy to negligible quantities; (2) selecting more vegetables (especially legumes) and novel meat alternatives (e.g., Beyond Meat Burger); and (3) avoiding deception by attributes of regionality, seasonality, and organic production that may not necessarily be valid indicators of food sustainability.

Overall, the results point to consumers' misconceptions regarding environmentally friendly food choices, which could best be addressed by policymakers, schools, and the media via cost-effective educational interventions. On the food industry side, our findings imply that a focus on sustainable food should not be pushed at the expense of offering delicious foods, as this is consumers' main concern during food selection. From a research methodology perspective, the study demonstrated the benefits of investigating "real-life" food selection processes (e.g., behavior at a buffet, and heuristic decision-making) to understand the complexities of consumers' behaviors. Future research could expand on this by investigating, for example, sustainable purchase behavior in a supermarket (e.g., via virtual reality (VR)) or

the influence of cooking skills (e.g., via cooking workshops) to increase plant-based diets (Overcash et al., 2018; Xu, et al., 2021).

6.1.2. Topic 2: Consumers' concern and awareness of palm oil and the RSPO label

Since many processed food products sold in supermarkets can contain unsustainable ingredients, eco-labels have the purpose of guiding consumers toward more sustainable options. However, although consumers claim to be interested in buying eco-labeled products, this is not always apparent in their shopping behaviors (Galarraga Gallastegui, 2002).

To explore factors contributing to this concern–behavior gap via a case study, Chapter 2 investigated Swiss consumers' concern and awareness about palm oil and the RSPO label. Overall, the study demonstrated that consumers view palm oil as highly problematic, especially in terms of its environmental impact. Most of the participants' associations with palm oil were negative and revolved around the fat's environmental detriments associated with land-use change (e.g., deforestation and biodiversity loss). When compared to other fats (coconut fat, butter, and canola oil), palm oil was perceived as the most problematic (e.g., in terms of sustainability, healthiness, and taste). Furthermore, consumers deemed it unacceptable that palm oil is an ingredient in many supermarket-sold products. These findings are in accordance with past literature revealing that consumers worldwide are highly critical of palm oil as an omnipresent—although often concealed—fat ingredient of food products (e.g., Disdier et al., 2013).

Despite this, consumers had little awareness about which products contain palm oil and about the RSPO label. While most consumers knew that palm oil was present in many sweet, high-fat foods (e.g., Nutella), they did not know that it could also be found in a large range of savory foods and non-edible products (Aguiar et al., 2018). Furthermore, hardly any of the participants had seen the RSPO label. In comparison, the recognition of two other eco-labels (UTZ and BioSuisse) was much higher. These results indicate that while consumers are concerned about palm oil, they lack the necessary awareness (about palm oil as an ingredient and the RSPO label) to make more sustainable palm oil-based purchases. Surprisingly, this concern–awareness gap was also evident among sustainability-oriented consumers. Specifically, even though consumers with high sustainability concerns were the most critical of palm oil, they were not more likely to recognize the RSPO label than an "average" consumer. This finding indicates that the RSPO label (an eco-label) is not even familiar to its target audience (i.e., eco-conscious consumers).

In summary, the study showed that although the consumers' concern for palm oil was substantial, they did not have the necessary knowledge to make more sustainable palm oil-based purchases. It was surprising that this applied even to sustainability-oriented consumers, seeing that it was particularly the environmental detriments of palm oil that were so controversial. Evidently, there is a significant need to improve consumers' awareness of palm oil (as an ingredient) and the RSPO label. Sustainability-oriented consumers may be the best target group to start with, as they may be most motivated to improve their knowledge of food sustainability in general and eco-labels in particular (Grunert et al., 2014).

At a broader level, the study highlighted which interventions ought to be prioritized to potentially increase the market impact of eco-labeling. Specifically, the literature discusses how, for instance, incentivizing consumers to buy eco-labeled products via payback schemes (Horne, 2009), establishing consumer accountability frameworks (Pedersen & Neergaard, 2006), increasing label trust (Gorton et al. 2021), or optimizing label design to better attract consumers attention (Rinh et al., 2019) could boost consumers' label use. However, the problem appears to persist on a much deeper level: While some labels may be widely recognized (the UTZ, for instance), others are in obscurity. This issue will need to be addressed before any other interventions (e.g., related to price, accountability, or trust) can be employed.

6.1.3. Topic 3: Factors correlated with consumers' WTC insects

To alleviate the environmental damage caused by the production of animal-based foods, consumers can choose to increase their reliance on alternative proteins. However, although insects, for example, have been consumed for hundreds of years in many parts of the world, their consumption is seen as taboo in Western countries. To gain an overview of the factors that contribute to this, the study presented in Chapter 4 reviewed past entomophagy literature. Specifically, the meta-analysis synthesized and quantified the correlates (i.e., factors) of the WTC insects reported in 37 studies. For each factor, a mean effect size was calculated ($\bar{r}$), and the number of studies contributing to this effect size (k) was recorded.

Affect-based factors had the strongest correlation with the WTC insects. Specifically, factors such as *food neophobia, food disgust*, and the *perceived risk of insects as food* had large mean effect sizes ($\bar{r}$ = -.33–.55) across many studies (k = 16–20). All of these factors are based on fear or disgust. While these two emotions can prevent us from consuming unknown and potentially harmful substances, they also contribute to the public's skepticism of potentially beneficial novel foods, such as genetically modified foods, cultured meat, and other alternative proteins (Siegrist & Hartmann, 2020).

Information-based factors were strongly correlated with the WTC insects. Specifically, we found that the *perceived sustainability of insects as food*, the *perceived healthiness of insects as food*, and the *perceived nutritiousness of insects as food* were positively correlated with the WTC insects ($\bar{r}$ = .32–.55). However, only a small number of studies have contributed to these mean effect sizes (k = 4–5). Therefore, the meta-analysis suggests that while education can increase entomophagy acceptance, the consistency of this positive effect is unclear. For example, it could vary depending on the type of information being given (e.g., providing a brochure vs. a workshop) or by the type of consumer being educated (e.g., children vs. adults) (Dupont & Fiebelkorn, 2020; Grasso et al., 2019).

Familiarity-based factors were moderately correlated with the WTC insects. Specifically, we found that one's *familiarity with the concept of eating insects*, or the *experience with eating insects* were positively correlated with the WTC insects ($\bar{r}$ = .10–.35, k = 3–14). This suggests that—following consumer education—gradual and/or early exposure to entomophagy is the second-best factor in promoting the acceptance of insects as food. However, as only a relatively small number of studies have investigated this variable, it is unclear what mechanisms resulted in this correlation (e.g., it is unclear whether mere familiarity with the concept of entomophagy or an actual taste experience impact WTC).

Curiosity-based factors were moderately correlated with the WTC insects. Specifically, *food sensation and innovation seeking* was positively correlated with the WTC insects ($\bar{r}$ = .29, k = 6). This was in line with the finding that both *food neophobia* and *food technology neophobia* negatively correlated with WTC. Humans can be ambivalent, and express both skepticism and curiosity toward novel foods (Rozin & Rozin, 1981). Our results suggest that exploiting this curiosity can be one approach to increase entomophagy acceptance, for example, by marketing insect products as something unique and exciting, or offering them to food neophiles at special "insect bars" or "bug banquets" (Brunner & Nuttavuthisit, 2019).

The factors that were least correlated with the WTC insects were sociodemographic variables (*age*, *education*, and *gender*) ($\bar{r}$ = -.14–.00, k = 13–20) and attitudes toward food, health, and the environment (e.g., *environmental concerns* and *health concerns*) ($\bar{r}$= -.03–.05, k = 2–3). Thus, it is questionable to what extent creating insect-based products targeted at specific consumer segments based on sociodemographic variables (e.g., insect-based weight-loss foods "gender marketed" toward women) or interest (e.g., insect protein shakes targeted at health-conscious consumers)—as suggested by previous literature (Verbeke, 2015)—can be a successful strategy to win first adopters of edible insects.

In summary, a large body of literature unanimously points to affect-based factors (e.g., neophobia, or disgust) being largely responsible for consumers' low WTC insects. Considering the strength of these barriers, entomophagy is perhaps one of the most difficult pro-environmental eating behaviors to promote on a global scale. Therefore, the prospects of insects as "food of the future" (Van Huis, 2016) in Western countries should not be overestimated. However, even though "the adoption of new foods comes with challenges, altering cultural tastes is not insurmountable" (Stull & Patz, 2020, p. 639). Educating consumers about entomophagy benefits, increasing their familiarity with entomophagy, and exploiting their curiosity can raise our societies' WTC insects to a certain degree. Nevertheless, since these factors are unlikely to impact the broad public, "focusing on willing early adopters may be more productive than trying to gauge factors that will affect acceptance in the general population" (House, 2016, p. 56).

Overall, the meta-analysis revealed that basic psychological correlates with the WTC insects (e.g., disgust) have been explored extensively. What future research ought to explore is how real-life interventions or product-specific variables can increase the appeal of edible insects. For example, schools could trial lectures concerning insects as food to encourage a new generation of consumers open to entomophagy (Dupont & Fiebelkorn, 2020). As another example, companies could dive deeper into product concept testing to explore, for instance, whether ground insects "disguised" in familiar Western foods (Orsi et al., 2019), or whole insects in "exotic" non-Western foods (Piha et al., 2018) are more accepted. Since the barriers to people accepting insects as food are substantial, researchers may want to investigate consumers' acceptance of other applications of insects within the food system (e.g., insects as animal feed, or their use for food waste management), as these applications may be easier to establish.

6.1.4. Topic 4: Product attributes that increase consumers' acceptance of novel MA-based foods

While MA are widely considered a promising future protein source, it is important to understand the factors that facilitate its adoption by consumers. In terms of geographical scope, Asia is perhaps the most promising market for novel MA-based foods. Chapter 4 investigated which attributes of such products increase acceptance via a case study of Singaporean consumers. The rationale for selecting Singapore for this survey was derived from the nation's initiative to promote alternative food types that could be produced in Singapore (Teng et al., 2019). Given the nation's inherent limitations in land resources, the effort to attain a certain

degree of self-sufficiency in the food supply has led to large investments in alternative protein technologies (e.g., MA, cultured meat) at the domestic level.

First, in terms of product type, Singaporean consumers appear to readily accept an MA-based meat or fish substitute. This is reflected in the survey results because "vegetarian/vegan products" and "meat alternative products" were the most frequently named associations with MA. Furthermore, meat consumption reducers (as compared to omnivores) had more positive associations with and a higher willingness to buy (WTB) MA-based foods, highlighting them as potential consumers in the future. Familiarity with vegetarian eating patterns and products increases consumers' acceptance of meat substitutes (Hoek, Luning et al., 2011; Schösler et al., 2012). Since plant-based eating practices (e.g., for religious reasons) and foods (e.g., tofu or seitan) are popular across Asia, a new MA-based meat alternative product could likely also have a high economic potential in Asian countries.

Second, an MA product that is compatible with traditional Asian cuisine may be welcomed by Singaporean consumers. Participants rated seaweed and tofu, which are traditionally Asian, as tastier, more natural, and cheaper than both beef and plant-based burgers. It is likely that these burgers, which originate from Western cuisine, were rated as less appealing due to Asian consumers' persistent preference for traditional over Western foods (Chang et al., 2010; Wang et al., 2016). Therefore, it is important that a novel MA product for Singapore is conceived as being distinct from Western meat substitutes currently on the market (e.g., Beyond Meat Burger), and as a product that aligns with local cuisine (e.g., fish balls, or satay).

Third, an MA product that is framed as innovative and trendy may be attractive to Singaporean consumers. Participants indicated that, out of five different aspects of an MA product, the innovative aspect convinced them the most to purchase. In line with this, consumers with a high motivation to eat "trendy" foods were most willing to buy an MA-based food product. This motivation was also found to be a driver of Singaporean consumers' WTB cultured meat (Chong et al., 2022). Interestingly, Asian consumers appear to have a more positive perception of food innovations in comparison to Western consumers (Bongoni, 2016; Bryant et al., 2019; Losada-Lopez et al., 2021; Rabadán & Bernabéu, 2021; Siegrist et al., 2015), who tend to perceive novel foods as unnatural and processed (Hoek et al., 2011; Siegrist & Sütterlin, 2017).

Fourth, an MA product that emphasizes sustainability and health benefits appears to be well received by Singaporean consumers. This conclusion is based on the finding that sustainability and health concerns positively predicted the WTB MA-based foods. Since

collectivist societies (e.g., most Asian cultures) tend to make food choices based on their relation to society (e.g., societal benefits or social standing) (Markus & Kitayama, 1991; Rahman & Luomala, 2021; Yoon et al., 2011), they may also be inclined to value their food's environmental friendliness, as this can bring societal benefits (Cho et al., 2013; Hofstede & Hofstede, 2001). Asians also tend to emphasize the health effects of diet, as demonstrated by the popularity of nutritional medicine (Anderson, 1988), and thus prefer foods with claims to have "additional health benefits" (vs. foods without this claim) (Siegrist et al., 2015). Interestingly, this effect appears to be the opposite for Western consumers, who are skeptical of foods with such health claims (Siegrist et al., 2015).

In summary, Singaporean consumers appear to accept an MA-based food product that is a meat/fish substitute; aligns with traditional Asian cuisine; is framed as environmentally friendly, innovative, and trendy; and has emphasized health benefits. Some of these attributes are not displayed or emphasized by modern meat substitute products currently available in the food industry (e.g., Beyond Meat), perhaps because they are created by Western companies and, thus, cater to Western preferences. As an outlook on relevant research, future studies may test MA product concepts in different Asian countries, run sensory tests with prototypes, and explore possible marketing strategies.

Overall, these findings demonstrate that consumers' perceptions of alternative proteins are not one-size-fits-all but instead depend on cultural context. Thus, to promote the adoption of alternative proteins on a global scale, research dedicated to this topic has to reach beyond its current focus on WEIRD (Western, educated, industrialized, rich, and democratic) societies (Henrich et al., 2010) and investigate perspectives elsewhere in the world. For example, since most modern meat alternatives were developed in Europe and North America, more research is needed on how these products can be tailored to appeal to non-Western consumers.

6.2. Implications

While the previous section discussed the central findings of each chapter separately, the following section explores some overarching implications of these findings for various actors of the food system, such as consumers, the food industry, policymakers, schools, the media, and researchers (see Figure 21). For this, the model by Chen and Antonelli (2020) describing factors that influence food choice (which was already discussed in the General Introduction) serves as a basis.

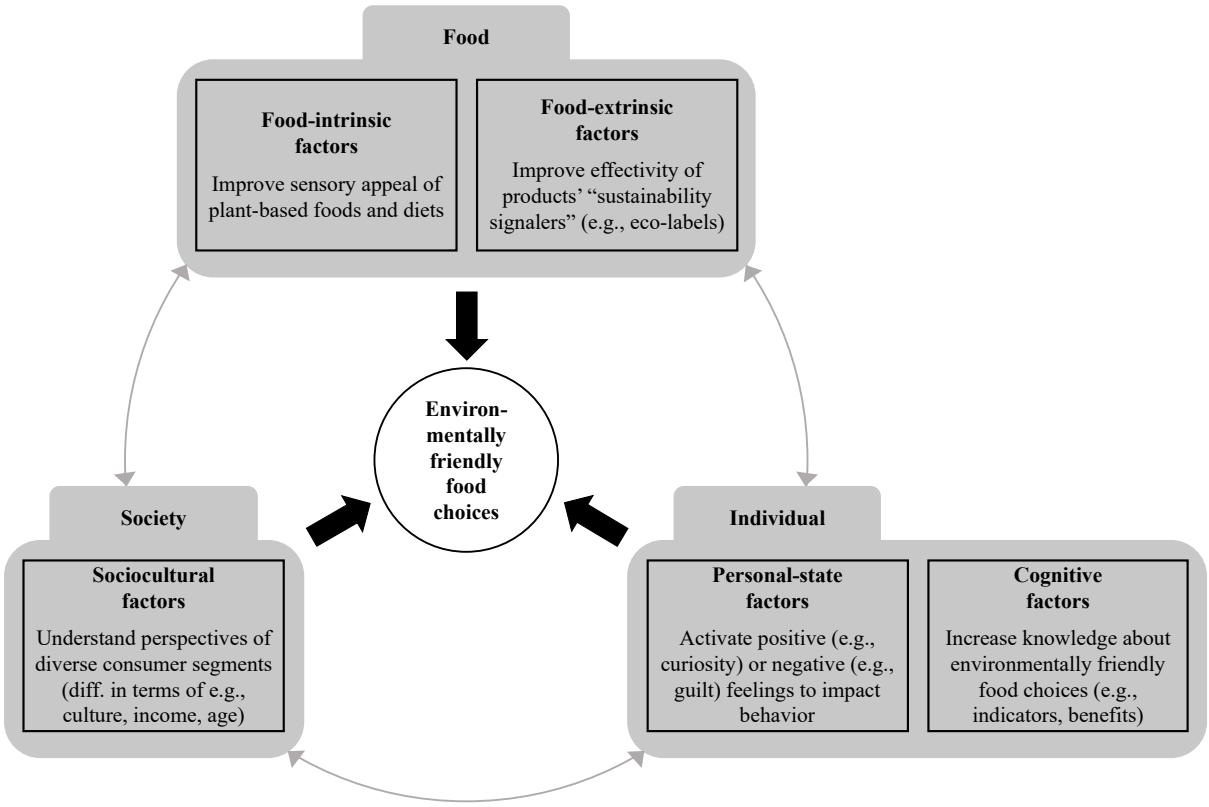

Figure 21. Implications of the central findings: Factors that could increase consumers' environmentally friendly food choices. The model is based on Chen and Antonelli (2020).

6.2.1. Food-related factors

Food-intrinsic factors, such as sensory features (flavor, taste, smell, and texture), will always be consumers' main criteria for food choices. Thus, the food industry will need to increase its efforts to improve the taste appeal of plant-based diets. Meat substitutes need to be drastically improved in terms of taste, texture, and smell. One approach could be to achieve a closer resemblance to meat. Another approach could be to create appetizing protein products that are not meant to directly mimic meat (e.g., tofu, seitan, or falafel) but instead stand as their own product categories. A benefit hereby would be that, by avoiding comparisons to conventional meat, consumers' taste expectations in the alternative protein product cannot be failed (Jahn et al., 2021). Food vendors, especially those catering to a large, regular audience (e.g., cafeterias), and their efforts to integrate novel alternative proteins into already popular foods/dishes and optimize the flavoring of these products, can substantially increase the public's acceptance (Tan et al., 2015; Tan et al., 2016). Also, it was shown that including taste-focused descriptions of plant-based options at university cafeterias (e.g., "Indulgent Deluxe

Salad" or "Mouthwatering Grilled Vegetable Wrap") significantly raised sales of these options (Turnwald & Crum, 2019). Overall, boosting the taste appeal and expectations of plant-based foods and diets is an important driver of the shift toward more sustainable consumption patterns.

Food-extrinsic factors, such as information "around" food (e.g., labels, or claims), should (in theory) nudge consumers toward more environmentally friendly choices. However, eco-labels are not always effective in doing so, even if the public claims to be interested in buying eco-labeled products (Pedersen & Neergaard, 2006). Although this gap is often attributed to the public's lack of knowledge about the meanings of labels (Grunert et al., 2014), consumers may just be unfamiliar with some labels (e.g., the RSPO label). To address this dilemma, improving the public's "label literacy" through informational campaigns is often discussed in the literature (Peschel et al., 2016; Vermeir & Verbeke, 2006). Innovative labeling schemes—e.g., displaying a product's eco-point score (Jungbluth et al., 2012; Leire & Thidell, 2005), illustrating environmental impact via a traffic light scheme (Engels et al., 2010), or even simply labeling a product as an "environmentally friendly choice" (Lazzarini et al., 2018)—have unfortunately not always had a considerable impact on consumer behavior. This is superimposed by other barriers (e.g., motivation, trust, or price) that constrain consumers' label use. For example, consumers have reported a low willingness to pay a premium price for certain label types (e.g., animal welfare) and certain eco-labeled products (e.g., meat, or seafood) (Li & Kallas, 2021). Overall, considering the limited market impact and high costs of eco-labeling, it is questionable whether these are efficient tools for creating behavioral change.

6.2.2. Individual-related factors

Personal-state factors, such as affect-based mechanisms (e.g., neophobia and disgust), are often the main barrier to consumers' adoption of environmentally friendly foods. In the case of insects, for instance, these affect-based barriers are so significant that they may even appear insurmountable (Shelomi, 2015). However, novel foods can also trigger positive emotions, such as curiosity, in certain consumer segments. For example, companies have been effectively able to boost interest in their insect-based products via public tasting events (Looy & Wood, 2006), while the thorough media coverage of cultured meat has immensely contributed to consumers' and investors' interest in the technology (Painter et al., 2020). In the same vein, utilizing negative emotions to influence consumers' purchases—an approach that the health sector already employs (e.g., graphic images of tobacco products)—may affect consumers' behavior. Specifically, consumers were less willing to buy meat products when

these carry disgust-eliciting images (depicting the potentially carcinogenic consequences of excessive meat consumption) (Koch et al., 2022) or guilt-eliciting messages ("animals are friends, not food") (Wang & Basso, 2019). Tools to nudge sustainable behavior often provide "emotionally neutral" information (e.g., eco-labels) to allow consumers to make rationality-based choices. However, activating a human's emotional system could be explored as a complementary strategy to impact sustainable behavior (Kershaw et al., 2023).

Cognitive factors, such as consumers' knowledge of food sustainability, are an important lever for facilitating long-term behavioral change. Governmental and educational institutions need to invest more heavily in educational interventions that improve consumers' pro-environmental eating behaviors, such as increasing vegetable and fruit intake (Nour et al., 2016), decreasing red meat intake (Carfora et al., 2017), and minimizing waste (Monroe et al., 2015). Web-based interventions, for instance, use mobile apps, e-mails, websites, and text messaging to provide informational material, personalized feedback, tips, and strategies for dietary behaviors (Kattelmann et al., 2014; Kerr et al., 2016). Alternatively, educational sessions can be held in clinics, supermarkets, or universities (Deliens et al., 2016; Liu et al., 2009; Van Assema et al., 2005). However, "providing nutrient-based information alone is inadequate. Most successful strategies have been the delivery of information in several smaller doses over time [and were] realized by focusing on positive 'to-do' behaviors, rather than on 'not-to-do' behaviors" (Dhandevi & Jeewon, 2015, p. 1315).

6.2.3. Society-related factors

Sociocultural factors need to be taken into greater consideration to formulate more realistic sustainable development measures. Specifically, with many of the environmentally friendly behaviors explored in this dissertation (e.g., meat and vegetable consumption), confounding economic and cultural factors need to be acknowledged. An increased vegetable intake, for example, may not be affordable to all consumers. Fresh produce can be limited in certain areas (e.g., "food deserts") and thus may be too expensive for lower-income households. One way to combat this could be to provide discounts to low-income consumers for the purchase of fruits and vegetables. Not only would this significantly increase the overall intake of these foods, but it would also create a larger market for producers (Moran et al., 2019). To illustrate another example, consumers' willingness to shift from meat to alternative proteins can be greatly affected by cultural norms. In many countries (e.g., middle-income, or non-Western countries), the consumption of beef or pork is perceived as a symbol of social status, whereas many nutritious foods are perceived as "poor man's foods" (e.g., legumes or

insects) (Jayasena & Abbas, 2016; Van Huis et al., 2022). Companies producing meat replacement products will have to take such cultural particularities into account to maximize their performance in a specific region. Overall, it will be important to tailor educational interventions and product development to specific consumer segments' wants and needs, instead of adhering to a one-size-fits-all approach.

6.3. Limitations

This current dissertation adheres to a specific perspective on food environmental friendliness, specifically, the one proposed by the EAT–Lancet Commission (2019), which places great emphasis on the global reduction of animal-based food consumption as the key to sustainable development. Since this perspective is the basis of the interpretations and implications proposed by this dissertation, its limitations need to be acknowledged: (1) Almost half of the world's land is considered unsuitable for agriculture ("marginal land"), making the role of livestock to secure food supply in these areas profound (Navarre et al., 2023). Thus, when it comes to recommendations for sustainable food production, viable regional/local solutions will have to be factored in as an integral part of a "global" solution. (2) Since the EAT–Lancet perspective focuses on the role of animal food production in improving dietary sustainability, less emphasis is placed on other foods and food-related factors that also significantly impact the environment. For example, since many crops are used as both food and feed (e.g., soybeans), their impact on the environment must be seen as a result of meat production/consumption and needs to be acknowledged as such. Furthermore, the increased use of pesticides (e.g., glyphosate) and their impact on nontarget organisms (e.g., pollinators and humans) can cause great damage to planetary systems (Maggi et al., 2020). (3) Apart from these environmental limitations, it is questionable to what extent the diet proposed by the EAT–Lancet (i.e., the PHD) is beneficial and feasible in terms of human health and the global economy. First, the PHD was found to be low in essential macronutrients, particularly those generally found in higher quantities and more bioavailable forms in animal-source foods (Beal et al., 2023). This is a shortcoming, especially for children, pregnant women, and low-income populations who rely on animal-based foods to gain enough nutrients and calories (Beal et al., 2023). Second, the PHD may not be affordable for poor communities, especially those living on marginal lands (Hirvonen et al., 2020). In these areas, livestock and fish production meaningfully contribute to food security, income growth, and gender equality (Adesogan et al., 2020).

Regarding interpretations of the research results, some methodological issues need to be considered: (1) Social desirability (i.e., the tendency for people to present themselves in a generally favorable fashion) is a potential limitation of most consumer research studies, especially when it comes to the investigation of pro-environmental behavior (Milfont, 2009). As it can bias both participants' self-reported measures and their performance in experiments, it could have affected both the results of the online and experimental studies included in this dissertation. (2) Certain issues need to be acknowledged concerning the food-related self-reported measures included in this dissertation (e.g., WTC and food frequency questionnaires (FFQs)). First, there may be large differences between consumers' reported willingness to eat and try certain foods as opposed to buying certain foods. This distinction is important to highlight, as this current dissertation often groups these variables under the overarching concept of "acceptance." Second, FFQ responses may be affected by conscious or unconscious underreporting or overreporting (Kristal et al., 2005; Willett & Hu, 2006). Consumers, for instance, tend to underreport their meat consumption (Lafay et al., 2000), especially when they have been primed about its' ethical and environmental detriments (Rothgerber, 2019). This is important to note because the participants in the current studies were asked to indicate their meat consumption via an FFQ and may have been biased by the apparent topic of the surveys (i.e., sustainable eating).

Moreover, the samples may not be representative in various ways: (1) Participants in all the studies were recruited from a research panel (i.e., a group of pre-selected people interested and willing to participate in a research study), which may have led to sample bias in terms of age, sex, and education. Specifically, panel-based samples tend to include more elderly women with relatively low formal education compared to young men with high education (Blasius & Brandt, 2010). (2) Since the studies were conducted in German (for the Swiss studies) and in English (for the Singaporean study), a language barrier may have distracted potential participants with low German or English proficiency. Consequently, the current samples may not be representative of their country of origin, as Switzerland and Singapore are multilingual. (3) Throughout this dissertation, the Swiss and Singaporean samples are often discussed as examples of Western and Asian societies, respectively. The degree to which these countries represent a greater set of societies is, of course, limited, especially considering that both Switzerland and Singapore have a small population and a very high gross domestic product compared to other Western and Asian countries.

6.4. Conclusion

History has seen numerous civilizations collapse due to their negligence toward the Earth. It is believed that the once great societies of the Maya, the Easter Islanders, or the Nauru nation, for instance, exploited and exhausted the natural resources of their habitat, and were left unable to sustain themselves. Not much appears to have been learned from the past, considering the immense environmental impact humans persist to exhibit, especially in the domain of food production and consumption.

However, throughout history, humans have also displayed the ability to drastically change their (eating) behavior for the better. When the potato, for instance, was introduced to Europe, the French people did not trust the new food. The tubers were perceived as strange and dangerous because they were grown underground and were avoided even by starving peasants. In fact, potatoes were officially banned in 1748, as they were believed to cause leprosy. It took several pioneering studies by the French pharmacist and agronomist Antoine-Augustin Parmentier to convince the nation of the vegetable's nutritional benefits, especially as a substitute for ordinary flour. As it staved off famine during poor wheat harvests, the potato quickly became a French dietary staple, and is now indispensable to the country's cuisine.

A dramatic transformation of eating habits is therefore possible. However, this transition must happen soon, and greater efforts are needed to move society toward more environmentally friendly eating habits. Increased attention should be paid to understanding the mechanisms underlying everyday food choice situations (e.g., making a meal, or grocery shopping), and our selection of proteins (animal- vs. plant-based), as these have an especially large impact on our environmental footprint. The current dissertation explored certain knowledge gaps regarding these topics, and proposes the following take-home messages:

- **Consumers' ability to choose environmentally friendly foods is limited by their misconceptions and biases**

Consumers are aware that decreasing their meat and fish intake can lower their environmental footprint. However, they lack nuanced knowledge and carry a set of biases (related to taste, or neophobia) that hinder them from optimizing their environmentally friendly food choice behavior. For instance, they are mostly unwilling to give up eating animal by-products (e.g., dairy), unwilling to adopt novel alternative protein products (e.g., plant-based burgers), and focus on unreliable indicators of sustainability (e.g., regionality). Resolving these misconceptions and biases is necessary to enabling a shift toward more sustainable eating habits. For this, future research may want to focus on improving the taste of sustainable

products (via sensory tests) and investigate "real-life" food choice situations (e.g., grocery shopping, or meal preparation, perhaps via VR), as these can reveal many complexities of human behavior better than survey studies.

- **The effectivity of an eco-label starts with consumers' awareness of the label**

Even though governments regard information as a silver bullet to improving consumer behavior, many informational tools are ineffective. Eco-labels, for instance, can only be effective if certain pre-requisites are met on the side of the consumers. These go beyond the obvious factors such as environmental concern: Public worry for certain food sustainability issues is not guaranteed to translate into their actions. Therefore, it necessary to increasingly consider consumer-related variables (e.g., label literacy, willingness to pay, or attention) in future research to evaluate or improve the effectivity of informational tools. It may also be beneficial to explore how other visual cues of a product (e.g., packaging design or material) can be used as "sustainability signalers."

- **Insects as "future food": Not anytime soon**

Much attention from researchers and the media has been directed to the potential of insects as "future food." However, looking at the entirety of the body of knowledge, it is unlikely that entomophagy will be a globally accepted practice anytime soon. Over the course of generations, slowly raising the acceptance of entomophagy could be possible. However, since the transition to more sustainable consumption habits is urgently needed, focusing on pushing insects as food may not be the best strategy for now. Instead, the acceptability of other applications of insects in the food system (e.g., as feed, or waste management) could be explored in future research, as this may be a more achievable than widespread entomophagy.

- **Alternative protein acceptance is not a one-size-fits-all**

When it comes to alternative proteins, both consumer research and the food industry have focused on (understanding and catering to) Western consumers. However, since many non-Western countries include various alternative proteins in their traditional cuisine (e.g., insects, soy, seaweed), it is likely that they represent a promising market for novel protein sources (e.g., cultured meat, microalgae). To tap into this potential, it will be important to consider culture-specific wants and needs during the development of such new products. For this, future research will have to increasingly consider the perspectives of consumers of all backgrounds (varying in terms of e.g., culture, income, or age) to improve dietary sustainability on a global scale.

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