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Consumers' perception of novel foods and the impact of heuristics and biases: A systematic review

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ABSTRACT

According to the definition adopted in the European Union, novel foods are foods that were not consumed to a significant degree within the Union before May 15, 1997. This includes cultivated meat and insects. Novel foods are meant to play a critical role in the transition towards sustainable food systems. However, their success depends on whether and to what extent they will be incorporated into the diets at the population level. This review investigates consumers' perception of novel food products by narratively synthesising results on the influence of heuristics and biases triggered by emotions, personality traits, and socio-cultural factors. Empirical studies conducted in Western countries and published in English after 1997 were eligible, which led to 182 studies being included. Notably, most included studies focused on insects and cultivated meat. Disgust and fear are shown to be the main emotions driving rejection of novel foods, together with food neophobia and specific cultural norms common across countries included in the scope of the review. Familiarity with novel foods and curiosity both led to higher acceptance. Despite being investigated directly in a minority of studies, heuristics and related biases mostly fell under the "affect," the "natural-is-better," and the "trust" heuristics. The review also discusses to what extent consumers' perception reflects in the regulatory framework applicable to novel foods in the European Union, how it influences the regulation of insects and cultivated meat and which lessons can be drawn for the future of the regulatory framework.

1. Introduction

With the European Green Deal, the European Union (EU) recognized the importance of transforming food systems towards sustainability in an era of increasing environmental concerns (European Commission, 2019). Alongside the traditional objectives of food safety and security, the Commission aimed to add sustainability and resilience. To accomplish these goals, novel foods are meant to play a critical role. Products categorized as novel foods such as insects or cultivated meat, have the potential to reduce greenhouse gasses emissions, water use and land use compared to traditional animal protein sources (Herrero et al., 2020; Mazac et al., 2022; Sforza, 2022).

Novel foods are foods that were not consumed to a significant degree within the EU before May 15, 1997 and that fall under one of the novel food categories (Regulation (EU) 2283/2015: Article 3(2)). The novel food definition encompasses several products and processes, which range from insects to nanofoods, plant extracts, foods obtained through new processing technologies, and products derived from cell cultures such as cultivated meat. Before being placed on the market, novel foods are subject to an authorization procedure to ensure their safety (Vapnek et al., 2021).

Novel foods' widespread adoption and success will to a large extent depend on consumers' acceptance. According to Kahneman (2003), individual judgement and consequent decision-making including but not limited to food choices are shaped by two cognitive systems that work in parallel: one is based on intuition, emotions, and past experiences (system 1); the other relies on reasoning and consideration of the available information and logic thinking (system 2). System 1 operates

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through heuristics, i.e. mental shortcuts that allow individuals to make fast decisions under uncertainty (Tversky & Kahneman, 1974). A wide range of heuristics governing human decision-making have been identified (Dale, 2015; Ehrlinger et al., 2016), particularly when facing unknown risks (Slovic et al., 2005). Since consumers have limited information to evaluate aspects such as food safety or the sustainability impact of the food they consume, heuristic thinking is their primary decision-making mechanism when approaching food choices (Scheibehenne et al., 2007). Siegrist and Hartmann (2020a) propose a framework that explains consumers' attitudes towards innovative technologies in the food sector through the influence of specific heuristics and biases. According to their analysis, three heuristics are especially important: the "affect heuristic," i.e. the tendency to rely on emotions when making decisions; the "natural-is-better heuristic," i.e. the preference for products not produced through technological processes; and the "trust heuristic," i.e. when preference for products is determined by trust in the source of information about the products (e.g., organic labels for organic foods) and not their characteristics, which are often difficult to assess for consumers.

This systematic review aims to extend this framework by identifying relevant emotions, personality traits, and socio-cultural factors that are the basis for these heuristics. Emotions are psychological and physiological responses triggered by specific stimuli or situations (Scherer 2005), often resulting in a behavioural response (Lerner et al., 2015). Emotions affect the evaluation of benefits and risks of an innovation (Valor et al., 2022) and serve as a heuristic in themselves (Rice et al., 2019; Winter et al., 2020). Importantly, emotions are subjective, state-like experiences. Personality traits, on the other hand, are stable patterns of thinking and feeling which characterize the behaviour of an individual across different situations and over time; yet they may be subject to a certain degree of change and development through new experiences (Caspi et al., 2005). Cultural factors and norms refer to the diverse and dynamic elements of a society's shared beliefs, values, customs, traditions, and practices that influence individuals' behaviors, preferences, and social interactions (Calhoun, 2002). All these factors contribute to the action of heuristics shaping consumers' perception of products categorized as novel foods in the EU.

1.1. Objectives of the systematic review

This review contributes to the growing body of literature which investigates acceptance of products categorized as novel foods. In particular, several recent reviews concern perception of product categories such as cultivated meat (Deliza et al., 2023; Kantono et al., 2022; Pakseresht et al., 2022; Siddiqui et al., 2022a), insects (Siddiqui et al., 2022b; Florença et al., 2022; Kröger et al., 2022; Mina et al., 2023), seaweed and milk alternatives (Siddiqui et al., 2022b; Rombach et al., 2023). Notably, these reviews focused on single categories of novel foods, which does not allow to compare consumers' perspectives towards different types of novel foods, or identify common motivations for consuming novel foods in general. Canavari et al. (2023) were the first ones to adopt the legal definition of novel food in a comprehensive manner to define the scope of their review, but they focused exclusively on factors shaping consumers' willingness to pay for products categorized as novel foods. In the present review, we use a broader conceptualization of acceptance of novel foods. Specifically, we went beyond the classical understanding of willingness to pay by also including willingness to eat, consumers' acceptance, perception, and attitudes towards novel foods as potential outcomes. Furthermore, we used the legal perspective to define both the scope of the research and for the interpretation of the results, to derive implications for policy making.

Since consumers' perception and narratives of disruptive innovations can influence the related social, regulatory, and political challenges (Stephens et al., 2018), understanding the psychological factors shaping consumers' perception and decision-making offers valuable insights into the regulatory framework applicable to such products. Given the importance of heuristics in decision-making in daily life, we specifically focus on the identification of relevant heuristics.

Thus, this review aimed to

- identify which heuristics and cognitive biases have been described in primary research on novel foods' perception;
- determine how such heuristics and related cognitive biases, together with other psychological factors, affect consumers' perception of novel foods;
- investigate to what extent such perception is reflected in the regulatory framework and which conclusions can be drawn for the future regulation of novel foods.

2. Methodology

The protocol for the review was pre-registered on the Open Science Framework (OSF) in December 2021 (https://doi.org/10.17605/OSF.IO/TNG8P). Raw data are available on the OSF page: https://osf.io/d856v/?view_only=ff8ae36000514811b2c640a0a26bd7f8.

2.1. Search strategy

In February 2022 the systematic literature search was conducted in four databases using the search terms listed in Table 1. The search terms reflected the most common novel foods and related psychological concepts and were refined after demonstrating face validity by retrieving key studies. The search was restricted to title, abstract, and keywords and to papers published after 1997.

In December 2022, forwards and backwards citation screening was conducted by one researcher (AM) through Google Scholar to identify relevant articles that were not identified through the initial search or that were published after the end of the search period.

2.2. Eligibility criteria and data extraction

Table 1
Databases and search query.

Databases	Search query
• Web of Science • Pro Quest • PsycInfo • Pubmed	("perception*" OR "attitude*" OR "acceptance" OR "consum* behavio#r" OR "consum* response" OR "willingness to consume" OR "willingness to buy" OR "consum* choice" OR "food choice" OR "heuristic*" OR "bias*" OR "neophobia" OR "neophilia" OR "yuck factor" OR "disgust" OR "trust" OR "naturalness" OR "unnaturalness" OR "aversion" OR "familiarit*" OR "preference" OR "food habit*" OR "rejection" OR "eating behavio#r*" OR "affect") AND ("novel food*" OR "algae" OR "edible fung*" OR "mycelium" OR "mycoprotein*" OR "innovative food*" OR "food innovation*" OR "cultured meat" OR "cultivated meat" OR "clean meat" OR "in vitro meat" OR "cell-based meat"OR "synthetic meat" OR "meat analogue*" OR "lab-grown" OR "plant-based protei*" OR "plant-based meat" OR "meat alternativ*" OR "innovative protei*" OR "alternative protei*" OR "entomophagy" OR "insects" OR "insect-based" OR "cheese alternatives" OR "milk alternatives" OR "plant-based milk" OR "food irradiation*" OR "Irradiated food*" OR "UV rays" OR "nanomaterial*")

As per pre-defined eligibility criteria, articles were considered relevant if they were published in a peer-reviewed journal, in English, between 1997[1] and the date of conducting the search, and reported on

[1] The decision to include studies published after 1997 was based on the date of entry into force of the first novel food regulation in the European Union (15th May 1997), Regulation (EC) No 258/97 of the European Parliament and of the Council of 27 January 1997 concerning novel foods and novel food ingredients.

empirical data collected in the EU or other Western countries[2] (Norway, United Kingdom, Switzerland, Iceland, United States, Canada, Australia, New Zealand) used to evaluate consumer perception (including consumers' acceptance, reaction, willingness to eat, pay and consume) of novel food products as per legal definition in the EU. Accordingly, articles were excluded if they were published in any other language, before 1997, or not in peer-reviewed journals. Reviews, meta-analyses and other overview articles were also excluded, as were studies conducted outside of the countries listed above. Studies were also excluded if they investigated foods that do not fall under the EU definition of novel foods, i.e. foods not consumed to a significant degree within the Union before May 15, 1997, or if they did not investigate consumer perception of these foods but only sensory analysis.

The screening of titles and abstracts and later full texts was conducted by two researchers independently (AM together with JK, AA, or MM). Data from all but n = 32 included studies were extracted by two independent researchers. Disagreements were resolved by discussion. The last thirty-two studies were extracted by one researcher, due to lack of resources and the absence of significant disagreement in the extraction of the previous articles. The extraction sheet is available on the OSF project page. Extracted information included: characteristics of the studies (quantitative, qualitative; between or within participants; observational or experimental; online or offline); details of the studies (study design), participants' details (age; gender; cultural background; economic conditions; food habits), results of the studies and any psychological explanation resulting that could possibly be related with consumers' perception of novel foods.

All studies were subject to a process of quality appraisal following respectively the CASP Checklist for qualitative studies (Critical Appraisal Skills Programme (CASP), n.d.) or the Checklist for Analytical Cross-Sectional Studies of the Johanna Briggs Institute (JBI, 2020), depending on the study design. Studies were included in the review independent of the quality rating achieved.

3. Results

3.1. Overview of included studies

The PRISMA flow diagram of records is depicted in Fig. 1. A total of $N = 182$ studies were included. Among them, n = 150 were the result of the first screening process, which led to the exclusion of n = 16123 studies after abstract screening, n = 15 studies for which full text was not available, and of n = 65 exclusions after the application of the eligibility criteria. The last n = 32 studies were retrieved through handsearching.

We adopted broad inclusion criteria to avoid missing relevant articles. For this reason, the final sample includes studies conducted in several Western countries and comparative studies, adopting diverse methodologies (qualitative vs. quantitative; observational vs. experimental) and which differ in terms of setups, number of participants, cultural background, and demographics. Most studies included in the review (n = 115) were conducted in countries within the European Union, particularly in Italy (n = 32), Germany (n = 18), Poland (n = 11), and the Netherlands (n = 10). Sixteen studies were comparative studies between countries within and outside of the EU, including the United Kingdom and Switzerland.

The vast majority of the studies used a quantitative research design. Only a minority of studies (n = 20) consisted of a qualitative design or combined qualitative approaches with quantitative attributes (n = 13). The majority of the studies (n = 158) were conducted online, or in a mixed online/offline setting (n = 18). Forty-two studies included tasting of products, either during the initial data collection or as a follow-up (n = 4). Some studies (n = 7) claimed to involve the consumption of novel foods, but the participants only tasted non-novel alternatives (e.g. bovine burger patties for cultivated meat; whole wheat flour instead of insect flour). With one exception, studies involving tasting covered only insect products or regular meat presented as cultivated meat. Studies on the latter are all hypothetical, since cultivated meat products, as of now, are not widely available on the market in any Western country.[3]

Studies mainly focused on two types of novel foods: insects and cultivated meat. Insect products in various forms (whole insects, flour) were the object of n = 116 studies, while n = 42 focused on cultivated meat, i.e., cultivated cell tissues from animals through lab techniques. Other investigated novel foods are nanofoods (n = 8), algae (n = 2), jellyfish and hemp (n = 1 each). Nine studies covered both cultivated meat and insects, n = 1 study compared insects with camel milk, n = 1 study insects with jellyfish and n = 1 study insects, jellyfish and cultivated meat. There is a tendency to compare novel foods with non-novel foods (n = 51), mainly with plant-based meat, and/or with other technologies like GMO foods (n = 2). Without making a direct comparison, three studies used GMO acceptance as a predictor for cultivated meat and nanofoods acceptance.

The review showed that the research on food innovations categorized as novel foods in the EU is developing steadily. Our review considers studies published between 1997 and 2022, but 137 of the 182 articles were published in or after 2019. In particular, studies covering cultivated meat increased steadily after 2019, while other technologies like nanofoods have been studied comparatively more before 2019.

Among studies covering insects, the majority focused on the cricket species *Acheta domesticus* and *Gryllodes sigillatus* and/or *Tenebrio molitor*, the yellow mealworm (n = 48 studies). Two studies covered the *Alphitobius diaperinus*, the buffalo mealworm. The other studies covering insects either did not specify which species were used in the research or focused on entomophagy in general.

3.2. Emotions, personality traits and socio-cultural factors in novel foods perceptions

3.2.1. The role of emotions in the perception of novel foods

Several emotions, i.e. physiological and psychological reactions to a stimulus or event, were related to novel foods. Disgust was by far the most common motivation for the rejection of novel foods, particularly when such foods are of animal origin, such as insects, but also for cultivated meat. Disgust is a basic human emotion, meant to protect us from potential danger hidden in unknown foodstuffs and thus included in our risk perception and evaluation mechanisms (Curtis, 2011; Rozin & Fallon, 1987). The majority of the studies (n = 98) included in the review focused on disgust as a predictor (Adamczyk et al., 2023; Ardoin & Prinyawiwatkul, 2020; Arena et al., 2020; Baker, Shin, & Kim, 2016; Balzan, Fasolato, Maniero, & Novelli, 2016; Barsics et al., 2017; Bartkowicz, Morska, & Gdyni, 2017; Berger et al.,2018a; Berger et al.,2018b; Berger et al., 2019; Bogueva & Marinova, 2020; Bryant et al., 2019b; Burt et al., 2020; Caparros Megido et al., 2016; Castro & Chambers, 2019a, 2019b; Cavallo & Materia, 2018; Chan, 2019; Cicatiello et al., 2020; Circus & Robison, 2018; Clarkson et al., 2018; Dupont et al., 2022; Egolf et al., 2019; Fischer et al., 2018; Franceković et al., 2021; Fuentes et al., 2020; García-Segovia et al., 2020; Gmuer et al., 2016; Gómez-Luciano et al., 2019; Gumussoy et al., 2021; Gurdian et al., 2021a; 2021b; Hamerman, 2016; Hartmann & Siegrist, 2016; Herbert & Beacom, 2021; Higa et al., 2021; Ho et al., 2022; Hocquette et al., 2022; Iseppi et al., 2021; Jensen & Lieberoth, 2019; Koch et al., 2021a;

[2] While the definition of novel foods used in this review is applicable only in the European Union, food consumption patterns and drivers of food choices are highly similar among Western cultures. To be able to include as many studies as possible, we decided to include studies conducted in any country with Western lifestyles.

[3] To our knowledge, at the moment of writing, in Western countries only one cultivated meat product was authorised in the US, and applications were submitted in Switzerland and Australia.

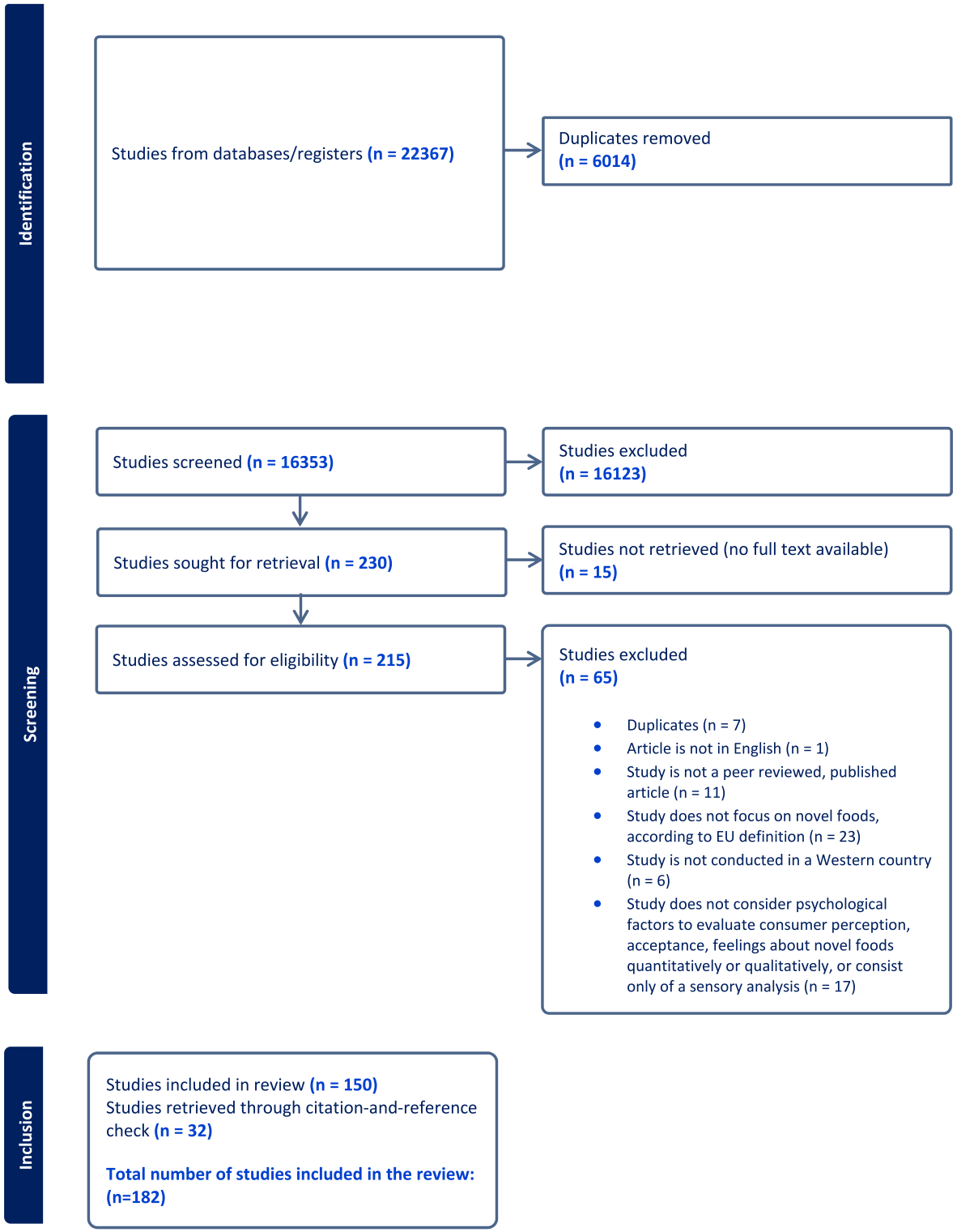

Fig. 1. Screening process for included studies.

Kornher et al., 2019; Kostecka et al., 2017; La Barbera et al., 2018, 2019; Laestadius & Caldwell, 2015; Lammers et al., 2019; Le Goff & Delarue, 2017; Lorini et al., 2021; Lupton & Turner, 2018a, 2018b; Malavalli et al., 2021; Mancini et al., 2019; Mazurek et al., 2023; Menozzi et al., 2017; Modlinska et al., 2020, 2021; Moruzzo et al., 2021; Music, 2021; Myers & Pettigrew, 2018; Naranjo-Guevara et al., 2021; Onwezen et al., 2019, 2022; Orsi et al., 2019; Palmieri et al., 2020; Piochi et al., 2022; Placentino et al., 2021; Poortvliet et al., 2019; Ritger et al., 2016; Ros-Baró et al., 2022; Rosenfeld & Tomiyama, 2022; Rovai et al., 2021, 2022; Ruby et al., 2015; Russell & Knott, 2021; Ruzgys & Pickering, 2020; Serpico et al., 2021; Siegrist et al., 2018; Siegrist & Hartmann, 2020b; Simion et al., 2020; Sogari et al., 2017; Sogari et al., 2019a; Szendrő et al., 2020; Tan et al., 2015; Torri et al., 2020; Tuccillo et al., 2020; Tucker, 2014; Ventanas et al., 2022; Verbeke et al., 2015; Videbæk & Grunert, 2020; White et al., 2023; Wilks et al., 2019; Woolf et al., 2019, 2021; Zheng et al., 2019; Zielińska et al., 2020, 2021; Çınar et al.,

2021).

The role of disgust in predicting rejection of novel foods was consistent across novel foods. The other predominant emotion covered by studies included in the review was fear. Fear referred either to the fear of contaminants or the fear of safety risks, particularly in studies focusing on insects (Ardoin & Prinyawiwatkul, 2020; Baker et al., 2016; Jensen & Lieberoth, 2019; Tan et al., 2015; Zielińska et al., 2020; Çınar et al., 2021), but also in studies covering cultivated meat (Laestadius & Caldwell, 2015; Malavalli et al., 2021); or both (Lupton & Turner, 2018a; Onwezen et al., 2022). When insects were the object of the study, disgust was mostly related to the fear of contamination (Balzan et al., 2016; Hamerman, 2016; Hartmann & Siegrist, 2016; Jensen & Lieberoth, 2019; Mancini et al., 2019; Myers & Pettigrew, 2018; Russell & Knott, 2021; Videbæk & Grunert, 2020). Framing of cultivated meat and insects as high-tech products also triggered fear and disgust (Bryant & Dillard, 2019; Zheng et al., 2019).

The focus across studies was almost always on negative emotions, although Onwezen et al. (2019, 2022), Schouteten et al. (2016), Serpico et al. (2021), Tuccillo et al. (2020), Ventanas et al. (2022) highlighted increased willingness to consume novel foods when positive emotions such as joy or feelings of adventure and freedom are associated with the experience.

3.2.2. *Personality traits: food neophobia, perceived unnaturalness and curiosity*

Personality traits, i.e. relatively stable internal characteristics, were also frequently related to the (negative) perception of novel foods. In n = 94 studies, food neophobia, i.e. the tendency to reject foods that are unknown or unfamiliar, was referenced as a predictor for rejection of novel foods (Adamczyk et al., 2023; Ardoin & Prinyawiwatkul, 2020; Asioli, Bazzani, & Nayga, 2022; Baker et al., 2016; Balzan et al., 2016; Bartkowicz, 2020; Boereboom et al., 2022a; Boereboom et al., 2022b ; Brunner & Nuttavuthisit, 2019; Bryant et al., 2019b; Califano et al., 2023; Caparros Megido et al., 2014; Caparros Megido et al., 2016; Castro and Chambers, 2019a; Cavallo & Materia, 2018; Cicatiello et al., 2016, 2020; Çınar et al., 2021; Clarkson et al., 2018; Conti et al., 2018; de Beukelaar et al., 2019; De Koning et al., 2020; Dupont et al., 2022; Elorinne et al., 2019; Fischer et al., 2018; García-Segovia et al., 2020; Gere et al., 2017; Gómez-Luciano et al., 2019, 2022; Grasso et al., 2019; Gurdian et al., 2021a, 2021b; Hamlin et al., 2022; Hartmann et al., 2015; Iannuzzi et al., 2019; Iseppi et al., 2021; Jensen & Lieberoth, 2019; Kornher et al., 2019; La Barbera et al., 2018, 2019; Lammers et al., 2019; Laureati et al., 2016; Le Goff & Delarue, 2017; Lombardi et al., 2019; Lundén et al., 2020; Lupton & Turner, 2018b; Mancini et al., 2019; Mazurek et al., 2023; Metcalf et al., 2021; Modlinska et al., 2020, 2021; Moruzzo et al., 2021; Music, 2021; Naranjo-Guevara et al., 2021; Onwezen et al., 2022; Orkusz et al., 2020; Orsi et al., 2019; Palmieri et al., 2023; Penedo et al., 2022; Piha et al., 2018; Piochi et al., 2022; Placentino et al., 2021; Ribeiro et al., 2022; Ritger et al., 2016; Rombach et al., 2022; Ros-Baró et al., 2022; Rovai et al., 2022; Ruby et al., 2015; Ruzgys & Pickering, 2020; Schäufele et al., 2019; Schlup & Brunner, 2018; Sidali et al., 2019; Siegrist & Hartmann, 2020b; Simion et al., 2020; Sodano et al., 2016; Sogari et al., 2019a, 2019b; Stone et al., 2022; Szendrő et al., 2020; Tan et al., 2016a, Fischer, et al., 2016; Tan et al., 2016b; Torri et al., 2020; Tuccillo et al., 2020; Tucker, 2014; Vartiainen et al., 2020; Ventanas et al., 2022; Verbeke et al., 2015; Verneau et al., 2016; Videbæk & Grunert, 2020; White et al., 2023; Wilkinson et al., 2018; Wilks et al., 2019; Zielińska et al., 2021). Food neophobia was measured through variations of the Food Neophobia Scale (Cicatiello et al., 2020; Elorinne et al., 2019; Gómez-Luciano et al., 2019; Orkusz et al., 2020), sometimes re-designed to focus on specific aspects, as for the insect Phobia Scale in Moruzzo et al. (2021).

Some studies (n = 10) focused also or exclusively on food technology neophobia, which refers to the feelings of distrust and aversion to consuming those foods that are the result of new technology applications (Boereboom et al., 2022a; De Koning et al., 2020; Dupont et al., 2022; Gómez-Luciano et al., 2019; Gorgitano et al., 2017; Kuang et al., 2020; Lammers et al., 2019; Modlinska et al., 2021; Rombach et al., 2022; Schlup & Brunner, 2018).

The theme of the rejection of products produced using new technologies such as cultivated meat or nanofoods was further studied across the review as "perceived unnaturalness" (n = 30 studies: Bryant & Dillard, 2019; Bryant et al., 2019a; Bryant & Barnett, 2019; Bryant & Sanctorum, 2021; Circus & Robison, 2018; Egolf et al., 2019; Franceković et al., 2021; Garcez de Oliveira Padilha et al., 2021; Gorgitano et al., 2017; Klöckner et al., 2022; Laestadius & Caldwell, 2015; Lensvelt & Steenbekkers, 2014; Lupton & Turner, 2018a, 2018b; Onwezen et al., 2019; Rosenfeld & Tomiyama, 2022; Ruby et al., 2015; Ruzgys & Pickering, 2020; Shaw & Mac Con Iomaire, 2019; Siegrist et al., 2018; Siegrist & Hartmann, 2020b; Siegrist and Sütterlin, 2017; Slade, 2018; Sodano et al., 2016; Tucker, 2014; Verbeke et al., 2015; Weinrich et al., 2020; Wilks et al., 2019, 2021; Wilks & Phillips, 2017). The concept of perceived unnaturalness is broader than the simple food technology neophobia and refers to the preference for products perceived as free from modern technologies' application or excessive human intervention, felt as evil and against the myth of a benevolent nature. Perceived naturalness was normally a predictor for rejection of novel foods, particularly cultivated meat, but also nanofoods (Egolf et al., 2019; Gorgitano et al., 2017; Sodano et al., 2016), and insect products (Lensvelt & Steenbekkers, 2014; Lupton & Turner, 2018a,b; Ruby et al., 2015). Some studies related perceived unnaturalness to feelings of disgust (Bryant et al., 2019a; Circus & Robison, 2018; Franceković et al., 2021; Laestadius & Caldwell, 2015; Rosenfeld & Tomiyama, 2022; Siegrist et al., 2018; Verbeke et al., 2015).

Contrary to food neophobia and perceived unnaturalness, curiosity, i.e. the innate desire to explore, try new experiences and learn new information, was studied as a predictor for willingness to consume novel foods (Lupton & Turner, 2018a,b; Modlinska et al., 2020; Nyberg et al., 2020; Palmieri et al., 2020; Penedo et al., 2022; Placentino et al., 2021; Possidónio et al., 2021; Ribeiro et al., 2022; Ritger et al., 2016; Rombach et al., 2022; Ruby et al., 2015; Sogari, 2015; Sogari et al., 2017; Stone et al., 2022; Tan et al., 2015; Videbæk & Grunert, 2020; Zielińska et al., 2021). Curiosity was either examined directly as curiosity for new experiences, or as neophilia towards new foods and acceptance for taking risks. It was related to a higher willingness to eat and try novel foods in most studies, with the exception of Palmieri et al. (2020).

3.2.3. *Familiarity, values and cultural influences*

Familiarity refers to the previous exposure and acquaintance with a novel food (Alba & Hutchinson, 1987). It was associated with higher willingness to try and consume novel foods in n = 47 studies (Ali & Ali, 2022; Ardoin & Prinyawiwatkul, 2020; Asioli et al., 2022; Baker et al., 2016; Barsics et al., 2017; Barton, Richardson, & McSweeney, 2020; Baum, Bröring, & Lagerkvist, 2021; Bekker, Fischer, Tobi, & van Trijp, 2017; Bieberstein, Roosen, Marette, Blanchemanche, & Vandermoere, 2013; Bryant et al., 2019b; Bryant & Sanctorum, 2021; Caparros Megido et al., 2016; de Beukelaar et al., 2019; Franceković et al., 2021; Gallen et al., 2019; Garcez de Oliveira Padilha et al., 2021; Gurdian et al., 2021a; Hartmann et al., 2015; Herbert & Beacom, 2021; Higa et al., 2021; La Barbera et al., 2018; Lammers et al., 2019; Laureati et al., 2016; Lorini et al., 2021; Lupton & Turner, 2018a,b; Mancini & Antonioli, 2020; S. Mancini et al., 2019; Modlinska et al., 2021; Naranjo-Guevara et al., 2021; Onwezen et al., 2019; Palmieri et al., 2019; Poortvliet et al., 2019; Possidónio et al., 2021; Schäufele et al., 2019; Schlup & Brunner, 2018; Simion et al., 2020; Steenis & Fischer, 2016; Szejda et al., 2021; Tan et al., 2015; Tan et al., 2017a; Tan et al., 2016b; Tan et al., 2017b; Verbeke et al., 2015; Weinrich et al., 2020; Wilkinson et al., 2018; Woolf et al., 2019, 2021). Some studies attempted to manipulate familiarity by providing information on the products. The provision of positive information regarding the products and its characteristics was shown to change the attitude of consumers towards novel foods (Bekker et al., 2017; Bieberstein et al., 2013; Iseppi et al., 2021; Laestadius & Caldwell,

2015; Mancini et al., 2019; Rabl & Basso, 2021; Sogari et al., 2019a; Verbeke, 2015). More specifically, informing about the environmental benefits and ethical aspects of the products reduced negative emotions like disgust or negative perception of unnaturalness (Barsics et al., 2017; Circus & Robison, 2018; Laestadius & Caldwell, 2015; Lorini et al., 2021; Naranjo-Guevara et al., 2021; Simion et al., 2020; Weinrich et al., 2020). Sometimes however, provision of technical information can be detrimental: Bryant & Dillard (2019), Franceković et al. (2021) noted how consumers were less disgusted by cultivated meat if less information about its production was provided.

Barsics et al. (2017), Hénault-Ethier et al. (2020), Jensen & Lieberoth (2019), Myers & Pettigrew (2018), Schäufele et al. (2019) and Stollar et al. (2022) noted that culture is a predictive factor for positive attitudes towards entomophagy, while Russell & Knott (2021) found a lower willingness to consume insects in presence of moral concerns. Circus & Robison (2018) found that moral and environmental concerns are strong motivators for consumers' willingness to consume cultivated meat, while conversely ethical considerations and feeling of unnaturalness can be predictors for rejection. Mancini & Antonioli (2020) did not find a direct relation between ethical appreciation of cultivated meat and willingness to consume. Bogueva & Marinova (2020), Çınar et al. (2021), Sogari et al. 2019a, and Tucker (2014) identified masculinity as a predictor for rejection of cultivated meat and insects; both types of novel foods were seen as a threat to the set of beliefs, values, attitudes, and behaviours associated with being male. With the exception of Çınar et al. (2021) these studies were conducted in Australia and New Zealand where the production and consumption of meat is of crucial economic importance. Finally, Wilks et al. (2019) relates rejection of cultivated meat to political conservativism.

3.3. Heuristics and biases linked to novel foods

Among the 182 articles included in the review, only n = 14 studies (Bieberstein et al., 2013; Egolf et al., 2019; Gallen et al., 2019; Hamlin et al., 2022; Kusch & Fiebelkorn, 2019; La Barbera et al., 2018; Legendre et al., 2019; Rabl & Basso, 2021; Ruzgys & Pickering, 2020; Siegrist et al., 2007, 2008; Siegrist & Sütterlin, 2017; Wilks et al., 2019, 2021) make direct reference to heuristics and biases. According to Siegrist and Hartmann (2020a), heuristic thinking can be linked to disgust sensitivity, food neophobia and cultural factors which shape consumers' individual perception of innovations. We thus adapted their framework for structuring our thematic analysis around the "affect," the "natural--is-better," and the "trust" heuristics. Importantly, many different heuristics have been listed in the literature, yet recent evidence indicates that they can often be subsumed under more general cognitive mechanisms, which is what we attempt to do in this section (Oeberst and Imhoff, 2023).

3.3.1. Affect heuristic

The "affect heuristic" occurs when the emotional state of people affects their evaluation of risks and benefits, which consequently influences their decision-making (Finucane et al., 2000). Egolf et al. (2019), La Barbera et al. (2018) highlighted the role of the dual-system for the perception of innovations and linked disgust with the impulsive System 1. Egolf et al. (2019) considered disgust as a direct trigger of the affect heuristic. Disgust drives people to unconsciously evaluate risks and benefits of novel technologies based on their (negative) perception, triggering the impulsive system rather than the reflective system. Siegrist et al. (2007) and (2008) also identified the perception of nanofoods to be shaped by the affect heuristic. Emotions and feelings evoked by nanofoods impact the perception of risks and benefits associated with them. Hamlin et al. (2022) highlighted the importance of the affective dimensions for the perception of cultivated meat.

The substitution of factual data with emotional assessments was also investigated by Kusch & Fiebelkorn (2019) and Gallen et al. (2019). Kusch & Fiebelkorn (2019) focused on two biases: the "negative footprint illusion" and the quantity insensitivity. The "negative footprint illusion" is the tendency of people to think that their food choices are more sustainable than they truly are (Gorissen and Weijters 2016). Similarly, quantity insensitivity refers to the inability of people to correctly estimate the environmental impact of a food (e.g., burger patties) based on both the property of the products (in this case, patties made from insects vs. meat vs. plant-based alternatives) and the consumed quantity (Kim and Schuldt 2018). Kusch & Fiebelkorn (2019) showed how burdensome mental processes and complex calculations are substituted with feelings originating from subjective experiences. Gallen et al. (2019) explained the mechanisms at the base of consumer perception of insect foods mainly through the contagion and the representativeness heuristics: The contagion heuristic is originated from the fear of contamination and disgust, while the representativeness heuristic increases consumers' acceptance when insect foods can be associated with known foods through visualisation.

3.3.2. Natural-is-better heuristic

Not all of the studies focusing on perceived unnaturalness make direct reference to heuristic literature, although they often imply an influence on decision-making. Specifically, perceived unnaturalness becomes a heuristic when natural products are considered healthier and tastier, using naturalness as a qualitative attribute for evaluating the novel food (Román et al., 2017).

Siegrist & Sütterlin (2017) specifically referred to a perceived unnaturalness heuristic shaping acceptance of cultivated meat. Consumers were found to be more willing to accept the risks associated with the consumption of traditional meat, because they perceived them as established and natural, while the risks derived from cultivated meat were perceived as new and unnatural. The role of the natural-is-better heuristic in the perception of cultivated meat was also highlighted by Wilks et al. (2019) and (2021). In Wilks et al. (2021) the authors further investigated perception of naturalness, and connected it to the dual-system model. They speculate that the naturalness bias originates in both systems, which means that it does not only relate to instincts. The naturalness bias was also seen as (deliberate) justification for feelings of wrongness or disgust, a finding confirmed by Siegrist et al. (2018). In both Wilks et al. (2019) and (2021) perception of unnaturalness did not always result in rejection on an individual level. Indeed, some people might be curious about trying foods produced through novel technologies.

3.3.3. Trust heuristic

The "trust heuristic" describes the tendency of people to substitute the evaluation of specific attributes of a given product or production process with the general trust towards those new technologies, which can be influenced by trust in the source of information (Sintov & Hurst, 2023). In their study, Rabl and Basso (2021) explored the impact of the producer's corporate social responsibility on the perception of cultivated meat. The research specifically investigated how the company's commitment to economic, social, and environmental sustainability influences individuals' perception of cultivated meat. While the effect of positive corporate behaviour was negligible, negative corporate behaviour lead to a substantial negative effect on consumers' attitudes towards cultivated meat, decreasing its acceptance. Siegrist et al. (2007) also highlighted that the level of trust towards the food industry impacts the perception of risks and benefits associated with nanofoods. Among studies not directly referring to heuristics and biases, Bieberstein et al. (2013) Bryant & Dillard (2019), Bryant & Sanctorum (2021), Lin-Hi et al. (2022, 2023), Siegrist et al. (2007) Siegrist et al. (2008), Siegrist and Hartmann (2020b), Siegrist & Sütterlin (2017), Sodano et al. (2016), Sogari et al. (2019a) and Zheng et al. (2019) also underlined the importance of consumers' trust towards companies and regulators for the acceptance of insects and cultivated meat. Some studies (Bogueva & Marinova, 2020; Sogari et al., 2019a; Wilks et al., 2019) have shown that rejection of insects and cultivated meat is sometimes due to the

influence of a conspiracy theory that suggests novel foods are being promoted as part of a hidden agenda to replace traditional foods for economic purposes. In Wilks et al. (2019) and Siegrist et al. (2018), distrust toward science was similarly identified as a strong predictor for cultivated meat rejection. Gallen et al. (2019) ascribed higher acceptance of insect foods to the influence of trusted authorities and loved ones.

In Bieberstein et al. (2013), familiarity positively correlated with increased trust toward science and technology and is shown to reduce negative risk perception and corresponding reactions. Legendre et al. (2019) noted that familiarity increased trust in media information and that heuristics help to filter relevant information to aid decision-making. Ruzgys & Pickering (2020) alluded to the "mere exposure" effect when discussing the perception of cultivated meat among young consumers. The "mere exposure" effect refers to accepting and incorporating foods into the diet as a result of having had the opportunity to taste them multiple times. Accordingly, marketing and promotional efforts offering consumers the opportunity to sample and taste novel technologies could promote their acceptance.

4. Discussion

In the present review, we adopted a legal definition derived from the EU regulatory framework to define the scope of the research. The final sample includes studies on consumers' perception of novel foods conducted in several Western countries and comparative studies, adopting diverse methodologies (qualitative vs. quantitative; observational vs. experimental) and which differ in terms of setups, number of participants, cultural background, and demographics.

The review provides an extensive overview of psychological aspects shaping the perception of novel foods. The majority of studies included in the review focused on insects and cultivated meat, for which disgust and fear, food neophobia and specific cultural norms are most often associated with rejection. Familiarity with these products as well as curiosity were correlated with higher acceptance. Although less frequently investigated, similar patterns seem to play a role for the acceptance of other novel foods such as nanofoods. Furthermore, despite being investigated in a minority of studies, heuristics and related biases are shown to be related to the identified relevant emotions, personality traits and cultural factors. The heuristics and biases addressed in the literature could be grouped into three categories: the "affect heuristic", the "natural-is-better heuristic", and "the trust heuristic".

Building on the main findings of this review, we now discuss to what extent heuristics and related psychological factors affecting consumers' perception of novel foods are currently reflected in the novel foods framework, assuming that the debate leading to policy-making decisions is also rooted in basic psychological principles.

4.1. Consumers' perception and the regulation of novel foods

The most consistent result across studies included in the review is the reluctance of consumers to consume novel foods. With no particular exception, studies showed that consumers are reluctant when asked to try, buy or consume novel food products such as insects, cultivated meat or nanofoods. Emotions like disgust and fear, and personality traits such as food neophobia and perceived unnaturalness of novel foods trigger the heuristics ("affect," "natural-is-better," "trust") identified in our analysis, which highlight a consistent pattern of rejection's elements.

Regulation (EU) 2283/2015 defines the framework applicable to novel foods in the EU. When the legislation was drafted, regulators had to determine the scope of the framework by adopting a definition of novel foods. They decided to include all food products not consumed to a significant degree within the Union before 1997 (Regulation (EU) 2283/2015: Article 3(2)(a)). Novel foods would then be subject to a pre-market authorization procedure. The authorization procedure has been criticized for being too complex, too long (taking up to three years), and too costly (Lähteenmäki-Uutela et al., 2021). Facilitated procedures are in place for a particular category of novel foods, the traditional foods from third countries, which are novel foods derived from primary production that have a history of consumption in a third country (Regulation (EU) 2283/2015: Article 14).

The decision to introduce a pre-market authorization system was taken to protect human health and consumers' interests. The definition of novel foods however does not immediately reflect a safety risk, but it introduces the element of "novelty" to determine what is considered risky (Monaco and P. Purnhagen, 2022). Thus, the decision to consider all products not consumed before 1997 in the EU as novel foods mirrors the food neophobia of consumers highlighted in this review.

Similarly, the decision to offer a facilitated procedure for authorizing products for traditional foods from third countries is limited to those novel foods derived from primary production, defined in the EU as "*production, rearing or growing of primary products including harvesting, milking and farmed animal production prior to slaughter. It also includes hunting and fishing and the harvesting of wild products*" (Regulation (EC) 178/2002: Article 3(17)). The decision to restrict the facilitated procedure only to such products reflects the importance of the "natural--is-better" heuristic.

Thus, the regulatory framework seems to mirror the heuristics shaping individual consumers' decision making. Slovic (1987) and Kuran and Sunstein (1999) have shown how heuristics and biases shape legislators' attitudes toward risks. Despite not being an exhaustive nor exclusive explanation for how Regulation (EU) 2283/2015 was drafted, the analysis of which heuristics and biases might have played a role in shaping the regulatory environment increases the comprehension of the legislators' decision-making processes.

4.2. Public debate on the regulation of insects and cultivated meat

In the EU, novel foods can enter the market if they are authorised through a risk analysis procedure, made by a risk assessment undertaken by the European Food Safety Authority (EFSA) and a final decision by political authorities, through a vote of EU Member States representatives in a dedicated committee (Regulation (EU) 2283/2015: Articles 10-13). Despite this rigorous and systematic framework, controversial novel foods like insects and cultivated meat have caused heated debates. This mirrors the results of this review, which showed that primary research on products categorized as novel foods has shifted almost exclusively to insects and cultivated meat: these two categories of novel foods have been the focus of the majority of the studies included in the review, while other novel foods received little to no attention.

For both insects and cultivated meat, the effects of the "affect heuristic" triggered by disgust and of the "trust heuristic" are crucial in the debate. In the case of insects, the feeling of disgust originates in them being seen as contaminants; this perception is culturally engrained in many Western societies (Rozin & Haidt, 2013). Thus, avoidance reactions to insects are typically learned at a young age, making the association difficult to delete or even flipped into a positive association (Jensen & Lieberoth, 2019). Due to the social nature of disgust, a clear example of which is the acceptance of insects by some cultures and their rejection by others van Huis (2013), Koch et al. (2021b) argue that information provision (e.g., about the authorization procedure ensuring safety of insect-based foods) is insufficient in reducing disgust.

The authorization of the products should indicate to consumers that the authorized products are safe. However, following the EU authorization of insect flour for uses in biscuits and pasta products, several conspiracy theories linked the promotion of insects' consumption with an attempt to destroy the national identity in Italy and Germany and called for their prohibition due to (unproven) safety risks (Hoffmann, 2023; Leardi, 2023). Likewise, the recent ban on cultivated meat production adopted by the Italian government may have been influenced by negative perceptions of this technology (Bertero et al., 2023; de Lorenzo, 2023). Since no EU-wide authorizations have been granted yet to any of

these products, the Italian government decided to act in advance by prohibiting the national production of cultivated meat, which seems more an attempt to gain approval from concerned voters rather than a decision based on scientific evidence. The concerns of the public are likely due to the complexity of the authorization procedure system, which might trigger feelings of unease, fear, and even distrust towards authorities (Herman et al., 2021).

According to the results of the review, familiarity seems to be the most reliable strategy to overcome disgust and trust issues. Public exposure to edible insects, and in the future cultivated meat, e.g. through public institutions, retailers and food producers, opinion leaders, and parents and caretakers, may establish new social norms regarding their consumption. While regulators may not directly influence these social norms through legislation, they can still have an indirect impact by establishing the necessary conditions that contribute to the formation of such norms.

4.3. Limitations

Our review presents some limitations. First, the number of studies testing the influence of heuristics and biases, or at least explicitly discussing them as a potential explanation for findings, is very low. The majority of the studies investigated factors like disgust and food neophobia, emotions and personal traits that lead to or are caused by heuristics and biases (Lerner et al., 2015). Primary research included in the review thus lacks insights into underlying psychological mechanisms that explain the connection between the various psychological factors and perceptions and behaviour through heuristics and biases.

Second, the consumers' acceptance of novel foods is not only due to the influence of emotional factors, heuristics and biases. Aspects as religious beliefs, socio-economic status, level of education and age may also impact consumers' food choices (Chen and Antonelli, 2020; Monterrosa et al., 2020). Future reviews should also take these aspects into account.

Third, included articles mainly focus on negative emotions and avoidance reactions, which provide valuable insights into why novel foods are not yet consumed. However, to depict a more complete picture, future research should address positive emotions and other influencing factors, like curiosity or familiarity, that improve the acceptance of consumers and their ability to overcome negative feelings. This could provide valuable starting points for interventions to promote the intake of novel foods.

Fourth, the research in the sector is dominated by two specific novel food categories: insects and cultivated meat. Only a small number of studies examined nanofoods, algae and jellyfish. Due to this imbalance, it is difficult to draw decisive conclusions as to whether the identified influences and mechanisms translate to other types of novel foods. Further, it must be noted that, in the EU, depending on the employed processes, cell-based products like cultivated meat or products of precision fermentation could potentially be classified as genetically modified organisms and not as novel foods (Ronchetti et al., 2024).

Finally, we only considered studies published in English. Studies published in other languages like Italian, German, French or Spanish, that might have fallen into the scope of the review have not been included in the review.

5. Conclusion

The review aimed to identify which heuristics and cognitive biases have been described in primary research on novel foods perception and determine how they, together with other psychological factors, affect consumers' perception of novel foods. Heuristics and biases are the explicit focus only of a minority of studies, but they can be related to the emotions, personality traits and cultural factors investigated in a larger number of studies. The results of the review must be interpreted by considering the predominant number of studies focusing on insects and cultivated meat, which are potentially more controversial compared to other novel foods, for example algae or plant-based protein extracts. Based on the studies included in this review, we conclude that disgust, fear and food neophobia are frequent reasons for the rejection of insects, cultivated meat, and nanofoods which trigger the action of different heuristics that we thematically cluster under the "affect," the "trust" and "the natural-is-better" heuristics. Yet, more studies are needed to test whether these findings also hold for other, less frequently studied novel foods. The regulatory framework applicable to novel foods in the EU reflects the consumers' perception of novel foods since it focuses on novelty and unnaturalness as key factors to determine which products should be regulated. However, the negative perception of novel foods remains even when products are authorized and proven safe. Increasing familiarity with novel foods like insects and cultivated meat seems to be the most effective way forward to increase consumers' acceptance.

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Ethical statement

This manuscript presents a comprehensive literature review, and as such, it does not involve original research or direct experimentation on human or animal subjects. Given the nature of the study, no ethical approval was sought or obtained, as it solely relies on publicly available and previously published data and information.

CRediT authorship contribution statement

Alessandro Monaco: Conceptualization, Data curation, Formal analysis, Project administration, Writing – original draft, Writing – review & editing. **Johannes Kotz:** Conceptualization, Data curation, Methodology. **Mirna Al Masri:** Data curation, Formal analysis. **Anila Allmeta:** Data curation, Formal analysis. **Kai P. Purnhagen:** Conceptualization, Supervision, Writing – review & editing, Funding acquisition. **Laura M. König:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

Declaration of Competing interest

The authors declare that they have no conflicts of interest associated with this manuscript. We affirm that there are no financial, personal, or professional interests that could be perceived as affecting the objectivity, integrity, or impartiality of the research.

Data availability

The data extracted from articles included in the review are available and the link is included in the manuscript

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.appet.2024.107285.

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