Novel Food Case Study in the EU: Exploring the Interplay Between Risk Assessment and Societal Insights for Communication

Paper first received: 09 February 2024; Accepted: 15 July 2024; Published in final form: 07 January 2025
https://doi.org/10.48416/ijsaf.v30i2.594

Marcello LAGANARO,[1,†] Giorgia ZAMARIOLA,[1,†] Esther GARCIA RUIZ,[1] Irene Nuin GARCIARENA,[1] Maria GLYMENAKI,[1,2] Alejandra Muñoz GONZÁLEZ,[1] Vânia MENDES,[1] Gabriela PRECUP,[1] Ruth ROLDÁN-TORRES,[1] Anthony SMITH,[1] Ermolaos VERVERIS,[1,3] Domagoj VRBOS,[1,*] and Andrea GERMINI[1]

Abstract

Recent advances in science and consumer demand for new or alternative food products boosted innovation in the food industry, stimulating the production of ever newer foodstuff. In the European Union (EU), when these lack a significant history of consumption, they may qualify as novel foods (NFs) and require a risk assessment by the European Food Safety Authority (EFSA) before they can enter the EU market. In this context, risk communication is crucial in ensuring the public understands any associated risks and requires different approaches according to societal knowledge and risk perception. We identified effective risk communication options for different NFs, accounting for societal insights, media analytics, and technical features. We applied an adapted version of EFSA's approach for planning risk communication of risk assessments' incoming requests on cell culture-derived foods and previously assessed NFs. The study included: categorization according to NF's nature, assessment of their mandates for their risk communication potential, identification of shared features across NF categories potentially triggering societal interest, and gathering of societal insights from literature and media analysis to map elements for risk communication. We recommend enhancing individuals' knowledge of risks through awareness-raising for NFs derived from microorganisms, fungi, or algae, produced with precision fermentation, derived from insects, or plants. For cell culture-derived foods, where public knowledge is higher, communication approaches should instead aim to build trust and resolve differences in views. We further highlight the importance of continuous dialogue between EFSA and stakeholders to ensure tailored risk communication that considers both scientific and societal factors.

[1] European Food Safety Authority (EFSA), Parma, Italy
[2] Department of Metabolism, Digestion and Reproduction, Faculty of Medicine, Imperial College London, United Kingdom
[3] Dept. of Hygiene, Epidemiology and Medical Statistics, School of Medicine, National and Kapodistrian University of Athens, Greece
[†] These authors have contributed equally to this work and share first authorship
[*] Domagoj Vrbos was employed by EFSA at the time research was conducted (2023)

Corresponding authors: Marcello Laganaro, marcello.laganaro@efsa.europa.eu and Andrea Germini andrea.germini@efsa.europa.eu

Bibliographical notes

Marcello Laganaro is a scientific officer working in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Giorgia Zamariola (PhD) is a social scientist working in the Communication Unit at EFSA, in the Strategic Communications team, providing social science advice and conducting social research to inform risk communication.

Domagoj Vrbos works as Team Leader of the Strategic Communications team at EFSA Communication Unit. His responsibilities relate to providing social science perspectives to different areas of EFSA's work, including generating insights from society that can support the delivery of trustworthy assessment and communication of risks from farm to fork.

Esther Garcia Ruiz is a scientific officer working in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Maria Glymenaki (PhD) is a trainee at the Nutrition and Food Innovation Unit at EFSA, and holds an honorary researcher position at Imperial College London, UK. Her research focused on the effect of gut microbiota and dietary and microbial metabolites in colorectal cancer, gut inflammation and weight loss surgery.

Vânia Mendes is a trainee working in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Alejandra Muñoz González is a trainee at the Nutrition and Food Innovation Unit at EFSA and is a PhD student in the research group of Food Chemistry at the Department of Food and Drug of the University of Parma. Her main research interests include food safety and food allergenicity assessment, specifically in gluten.

Irene Nuin Garciarena is a scientific officer working in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Gabriela Precup (PhD) is a scientific officer in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Ruth Roldán-Torres is a scientific officer working in the Nutrition and Food Innovation Unit at EFSA, in the Novel Foods team, dealing with the risk assessment of novel foods.

Anthony Smith is a risk communication scientist working in the Communication Unit at EFSA, in the Strategic Communications team. His role entails using social research insights to develop communications approaches and to contribute to strategic communication planning and operations.

Ermolaos Ververis is a scientific officer in the Nutrition and Food Innovation Unit at EFSA, working on the risk assessment of Novel foods. He coordinates activities on insect- and cell culture-derived foods, as well as food compositional characterization. His PhD studies are in the field of Risk-Benefit Assessment and Public Health.

Andrea Germini (PhD) is a senior scientific office in the Nutrition and Food Innovation Unit at EFSA, where he coordinates the activities of EFSA in the area of Novel foods and leads the team on Novel foods - product characterization.

Introduction

Recent advances in science and consumer demand for new or alternative food products have boosted research and innovation in the food industry, stimulating the production of ever more new foods, food ingredients, and food supplements. Under European Union Regulation (EU) 2015/2283[1], foodstuffs that were not consumed to a significant degree before 15 May 1997 qualify as novel foods (NFs). NFs can be produced using new technologies and processes, derived from new sources, be newly synthesised or isolated substances, or foods traditionally consumed in non-EU countries.

To protect European consumers from potential health risks linked to the consumption of such products, the current EU framework requires food business operators to seek premarket authorisation for their NF products before these can enter the EU market. The European Food Safety Authority (EFSA) is the EU body responsible for providing independent scientific advice to decision-makers during the NFs authorisation process. EFSA performs scientific risk assessments and communicates the outcomes. Each risk assessment follows a structured, multidisciplinary, and evidence-based approach (EFSA NDA Panel, 2021a; Ververis et al., 2020). All EFSA's assessments are then communicated through scientific opinions published in the *EFSA Journal*[2]. In addition to the scientific publication, some risk assessments may be accompanied by targeted risk communication activities, depending on the topic and the findings.

As defined by the Codex Alimentarius (2003), risk communication is "the interactive exchange of information and opinions concerning risk and risk-related factors among risk assessors, risk managers, consumers, and other interested parties". EFSA's risk communication aims to support EFSA stakeholders,[3] risk managers and the public in understanding the reasoning behind science-based assessments and subsequent decisions. Consumers are thus able to make informed choices and control the risks they might encounter, according to their interests and values. Risk communication by EFSA is not intended to persuade people to adopt specific views on risk tolerability or acceptability. It rather serves to promote safe product use, build and enhance trust in risk assessment and risk management, improve public understanding of food safety, and empower consumers to make informed decisions.

Consumers' knowledge and perception result in purchase choices, which may or may not lead to the consumption of NFs. Individual consumption decisions are the outcome of multiple cognitive response layers (see Boehm et al., 2021 on insects; Camarena et al., 2011; EFSA Scientific Committee, 2022). For example, European consumers prioritise food safety and traceability, but personal values and beliefs play a crucial role in affecting food risk perceptions. These factors have been the focus of social research studies on NFs perception and food neophobia (for an overview, see Donadini et al., 2021; Rozin and Vollmecke, 1986; Pliner and Salvy, 2006; Tuorila and Hartmann, 2020). In this context, effective risk communication requires the integration of social science research findings, which consider individual and culturally specific values when raising consumers' awareness, and which support appropriate knowledge and perception of the risk.

For this reason, in the area of risk communication, and in line with the International Risk Governance Center's (IRGC) conceptual framework for understanding risk governance (Florin and Bürkler, 2017; Florin and Parker, 2020), EFSA developed a two-phase approach: Pre-Assessment (Screening), and Appraisal (Risk Perceptions and Social Concerns Assessment). This approach is based on the use of societal insights, analytics, and professional knowledge for assessing incoming risk assessment requests and optimising the planning for its subsequent risk communication (Vrbos et al., 2023). The risk communication's Pre-Assessment phase consists in screening and filtering risk assessment requests using a checklist to determine risk characteristics,

[1] Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001.

[2] https://efsa.onlinelibrary.wiley.com/

[3] https://www.efsa.europa.eu/en/engage/stakeholders

public awareness and knowledge, and institutional/market context. A decision tree prompts future risk communication preparations. The Appraisal phase involves gathering societal insights from social research and media analysis to chart elements for risk communication and evaluate the overall sensitivity of the topic. These two phases identify risk communication topics and clusters of interest, create communication objectives and strategies, and, ultimately, aim to lead to standardised communication responses on specific topics.

In the present work, we applied an adapted version of the two-phase risk communication framework described in Vrbos et al. (2023), to NFs that have already been assessed by EFSA and for which published risk assessment outputs are available. These include NFs derived from: microorganisms, fungi, or algae; insects; and plants as well as NFs with modified molecular structure. We were thus able to implement an intermediate phase beyond the standard Pre-Assessment step, by also examining the scientific content of final scientific opinions on NFs. This enabled us to attempt to identify the scientific characteristics of potential public interest.

Additionally, with a view to developing effective risk communication approaches for upcoming NFs, our analyses also considered rapidly evolving fields for food production in areas such as cell culture-derived foods (i.e., food production by the reproduction of animal or plant cells, assisted by tissue engineering techniques) and precision fermentation (referring to the use of engineered microbial cell factories in the production of foodstuffs).[4]

The overall scope of our work was to explore and identify risk communication options that could be effective in addressing the respective observed levels of knowledge and perception for different categories of NFs. To ensure that these communication approaches are tailored to NFs that have shared technical characteristics (e.g., source material, production process) and risks, we considered the interplay between societal insights and media analytics, as well as scientific aspects.

Methodology

Novel food mandates - collection and categorisation

We retrieved NF mandates (i.e., EFSA's incoming risk assessment requests from the EC) falling under Regulation (EU) 2015/2283 and related scientific outputs published from 1 January 2021 to 8 May 2023 (the date on which the data extraction was performed), from the OpenEFSA Portal.[5] The search keywords included "Novel Foods" for the food domain and "Novel Food Authorization" for the authorisation type. By selecting the appropriate status filter, we considered only published NF outputs for which the risk assessment had been completed. We excluded ongoing risk assessments, withdrawn applications, and notifications for traditional foods from third countries.

We classified the resulting NFs according to their nature or that of their source, following the most recent classification described in Article 3 of Regulation (EU) 2015/2283. In brief, each NF was classified using a simplified terminology: a) "Modified molecular structure"; b) "Derived from microorganisms, fungi or algae"; c) "Mineral origin"; d) "Derived from plants or their parts"; e) "Derived from animals or their parts"; f) "Derived from cell or tissue culture"; g) "Derived from novel production process"; h) "Engineered nanomaterials"; i) "Vitamins, minerals and other substances", and j) "Foods other than food supplements".

Societal insights in risk communication

We assessed the retrieved NFs by applying an adapted version of the two-phase approach developed by EFSA and described in Vrbos *et al.* (2023) as follows:

[4] https://www.efsa.europa.eu/en/events/efsas-scientific-colloquium-27-cell-culture-derived-foods-and-food-ingredients
[5] https://open.efsa.europa.eu/.

Phase One: mandates assessment of novel foods

Mandates assessment

In the mandates assessment step, we evaluated the requests for scientific risk assessments with a "yes/no" answer to the checklist criteria listed in Table 1 below.

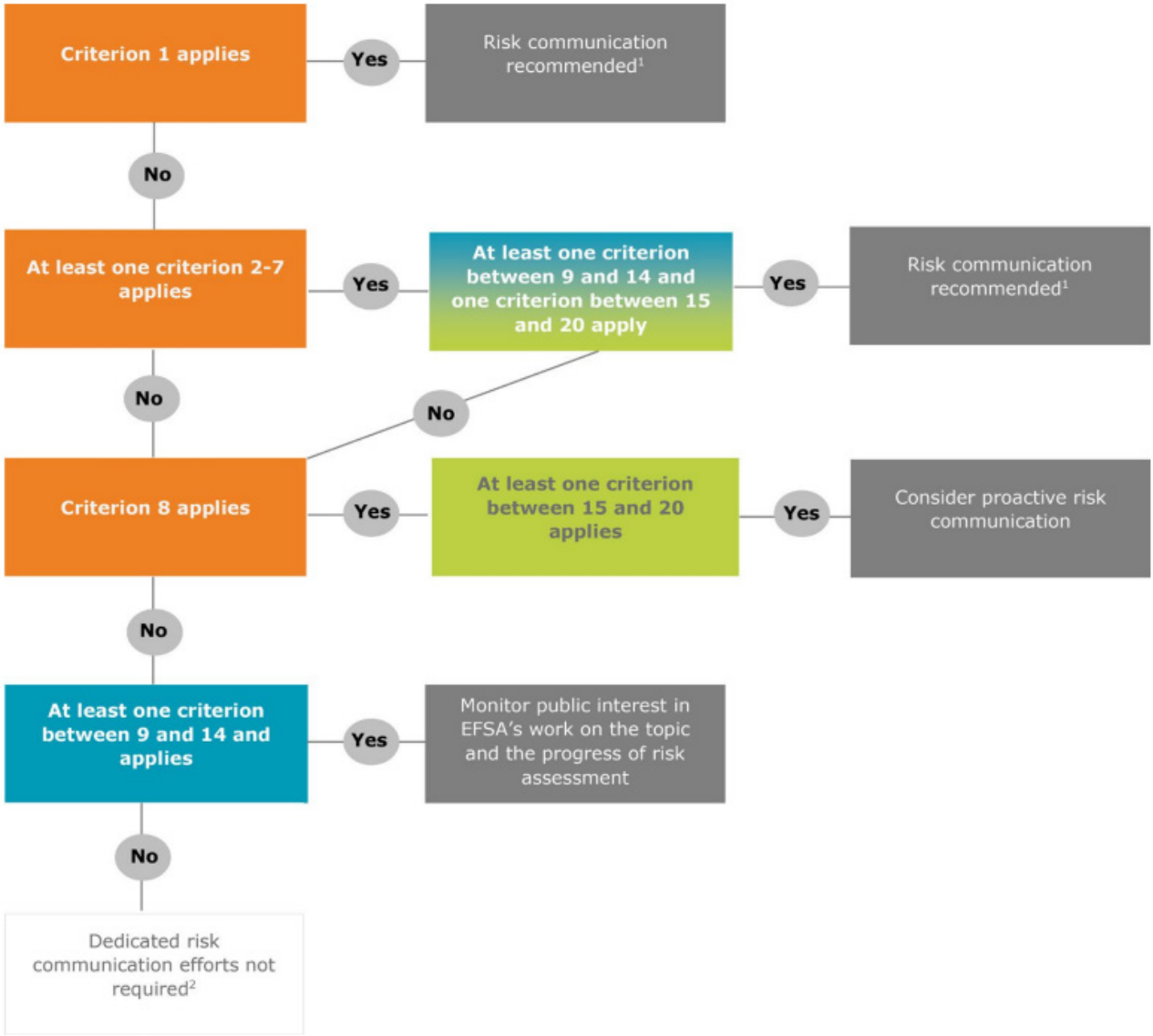
Table 1 – EFSA Checklist for assessing incoming mandates. From Vrbos et al. (2023)

Criterion	Yes/No
i. Nature of the topic	
1. Is there (potentially) a significant concern for public health and/or does the risk affect specific vulnerable groups (e.g. pregnant women, children)?	
2. Is there (potentially) a significant concern for animal health, animal welfare, plant health or the impact on the environment?	
3. Is the risk man-made (as opposed to naturally occurring)?	
4. Is the risk emerging/unknown?	
5. Is this the first time EFSA will assess the risk?	
6. Is this an urgent request or a Rapid Outbreak Assessment?	
7. Is this an assessment of a risk that is commonly present in everyday diets or in general a ubiquitous substance?	
8. Does this topic have the potential to communicate the benefits of EFSA's work (highlighting one or more of its values) or the importance of the EU's food safety system?	
ii. Knowledge and perceptions	
9. Has the topic gained significant visibility based on media exposure to date or is it a prominent topic in social media?	
10. Is there a known pre-existing societal concern around this topic?	
11. Are there known disagreements or diverging views on this topic (among scientists, within society groups, between scientists and society)?	
12. Are there known uncertainties related to this topic?	
13. Does this topic have the potential to negatively affect EFSA's reputation (i.e., could EFSA be questioned in terms of conflict of interest or level of transparency etc.)?	
14. Does available social research evidence (e.g., EU Insights, Eurobarometer, other recent studies) highlight the topic as an area of concern?	
iii. Institutional and stakeholder interest	
15. Is this topic of interest or concern for the European Commission and/or does it have risk management implications?	
16. Is this topic of interest or concern to the European Parliament?	
17. Is this topic of interest or concern to Member States' authorities?	
18. Is this topic of interest or concern to civil society (e.g., consumers, NGOs, or other interest organisations)?	
19. Is this topic of interest or concern to the scientific community?	
20. Can the assessment result in policy changes and/or have market impact?	

Ascertaining knowledge and perceptions regarding specific topics posed a significant challenge in our study due to the limited media exposure and lack of sociological research insights. This was primarily because these topics were predominantly related to new technologies only recently introduced to the EU. Media coverage

existed for crickets and ground mealworms, the sole items featured in EFSA's risk communication activities over the previous five years because they were among the first completed insect assessments in the EU. No other NFs showed more than limited evidence of a societal interest or concern. To address this lack of data, we included an additional step for criterion 9 in our protocol. This involved passing the NFs through a social media monitoring tool[6] by inserting a search string consisting of the NF denominations in English. Examples of keywords used for this step included "novel food" AND "mealworm" OR "shiitake mushroom" OR "mung bean protein". We ran these search strings using a feature in monitoring tools that enables the identification of social media trends. The aim of this step was twofold: first, to determine if the online discourse about certain NFs was more prominent than that about others; and second, to identify NFs within each category that had a relatively high volume of social media activity.

Figure 1 - Incoming mandates decision tree. From Vrbos et al. (2023). Instructions: Complete the checklist (Table 1), assessing the mandate across all 20 criteria. Then follow the decision tree below, considering 'Nature of the topic' (criteria 1–8) as the starting point.



[1] *Follow-up required with Scientific Unit for familiarisation with the mandate and planning of risk communication activities. This may result in deployment of one or more tools from EFSA's communication toolkit.*

[2] *Staff are encouraged, however, to promote EFSA outputs such as those they are involved in, via social media, to reach niche audiences and build peer-to-peer networks.*

Following the decision tree for incoming mandate assessment displayed in Figure 1 (Vrbos et al., 2023)

[6] https://www.efsa.europa.eu/sites/default/files/documents/legal/dp/dp-COM5.pdf.

according to the answers provided in the checklist (Table 1), we identified those NFs warranting the potential consideration of risk communication activities and we further investigated them in the successive phases of the evaluation. We note that in practice EFSA does not proactively communicate on assessments of individual NFs submitted as part of an EU market authorisation procedure, other than publication of the final scientific opinion. However, for the sole purpose of this research, we ignored this common practice and assessed individual NFs and their mandates as if supplementary proactive communication were possible.

Intermediate phase: Shared features triggering societal interest

We further screened the NFs that were identified as requiring risk communication activities, based on the outcome of the decision tree presented in Figure 1. This screening aimed to identify shared technical and/or scientific features that could potentially explain the relatively high volume of social media discourse observed for some NFs compared to others.

This analysis had three main objectives: i) to allow for examination of discourse on the NFs most featured on social media, from among all those retrieved in phase one; ii) to identify common features within the same NF category that might contribute to social media prominence and public sensitivity; and iii) to select keywords that could enrich the subsequent analysis (see phase two: appraisal phase).

Phase Two: Appraisal phase

The appraisal phase had two objectives: first, to map the elements to consider for risk communication; and second, to identify the overall degree of sensitivity of the subject matter, considering concerns, expectations and risk perceptions.

NFs that warranted risk communication activities according to Figure 1 were considered in the phase two analysis. However, in the appraisal phase, due to the granularity of available data, and to draw more general conclusions, we focused on NF categories as described in Article 3 of Regulation (EU) 2015/2283 and/or the key shared characteristics identified in the intermediate phase, rather than on individual NFs. We assumed that NFs share common features in terms of public sensitivity across the same category. Therefore, we used proxy keywords for the category itself (see the social research data and public discourse sections).

Furthermore, assuming a potential increasing prevalence of NFs in the coming years, the "Derived from cell or tissue culture" NF category was included and further analysed.

Finally, in phase two, we also investigated NFs in general. Importantly, we included "alternative proteins" (i.e., those not derived from traditional sources such as animals or legumes) in the research activities. While they may not necessarily fall into a specific category of NFs, we considered them as they have the potential to qualify as such. Additionally, we noted that these alternative proteins are often the subject of social media discourse as they can impact consumption behaviours and have societal implications related to animal welfare and climate change (Siegrist and Hartmann, 2023). It should be noted that the term "alternative" was used for literature search purposes only and does not imply any judgment or bias regarding the suitability of alternative proteins as substitutes for traditional protein sources in diets. "Alternative proteins" was used as a proxy for "Novel proteins" due to its more widespread usage and representation in the existing body of published literature. It was also assumed that the term "alternative", would also cover "novel proteins" – thus retrieving relevant literature.

Social research data

To explore public perceptions of NFs, we performed a scientific literature search on Google Scholar using the following keywords: "novel foods" OR "alternative proteins" OR "cell culture derived food" OR "cultured meat" OR "lab-grown food" OR "edible insects" OR "plant-based food" OR ("precision fermentation" OR

fungi OR algae AND food) AND "risk perception" OR "attitude" OR "concern". Google Scholar was used as it is a free access literature search engine, ensuring that our search is transparent and can potentially be replicated by other scientists without restriction due to access to paid databases. We focused on recent literature published in the last ten years in scientific peer-reviewed journals, and we assessed the first 20 pages of the search. The decision to include the first twenty pages was based on the authors' experience conducting similar reviews and the assessment of the relevance of the identified papers for this specific work. We selected the articles based on title screening first, and the abstract as the second selection criterion.

Public discourse

We conducted the social media analysis with the social media monitoring tool,[7] however using a feature that allows tracking of a topic over time. Our analysis of the social media discourse related to NFs covers the same timeframe as the collection of NF outputs (i.e., 1 January 2021 to 8 May 2023), and includes data from the social media network X in all EU countries.[8] The social media query on NFs is available in Annex A. It includes keywords in English related to novel food, translated into French, German, Italian and Spanish.

The social media monitoring tool provides the social media volume, that is, the exact number of posts in a given period. Likewise, it provides social media engagement. An engagement is considered as a reaction to a post such as a repost, a share, a reply or a comment. Additionally, the tool presents information on the sentiment over a given period. The sentiment is rated by the social media monitoring tool on a scale from -50 to +50, where a score from -50 to around -15 indicates negative sentiment, from -14 to +14 indicates neutral, and from +15 to +50 indicates positive.

Filters could be applied in the social media monitoring tool to select specific segments of the data, for instance, those focusing specifically on one subtopic of the query or data coming from a specific geographical area.

Risk communication advice

Once the topic profiling was finalised, we calculated a value of concern by positioning the topic on a two-axe graph with knowledge on the x-axis and risk perception on the y-axis.

'Knowledge' includes four types of information gathered through the assessment: 1) self-reported awareness; 2) self-reported knowledge; 3) objective knowledge; and 4) social media volume. Based on the findings of the assessment, a value of −1 (low), 0 (medium), or +1 (high) was assigned through expert judgment to each type of information.

The same system was applied for 'Risk perception', which also includes four types of information: 1) self-reported concern; 2) self-reported importance; 3) self-reported interest; and 4) social media sentiment. Mirroring the process explained above for 'knowledge', a value of −1 (low), 0 (medium), or +1 (high) was assigned through expert judgment to each type of information.

Results & Discussion

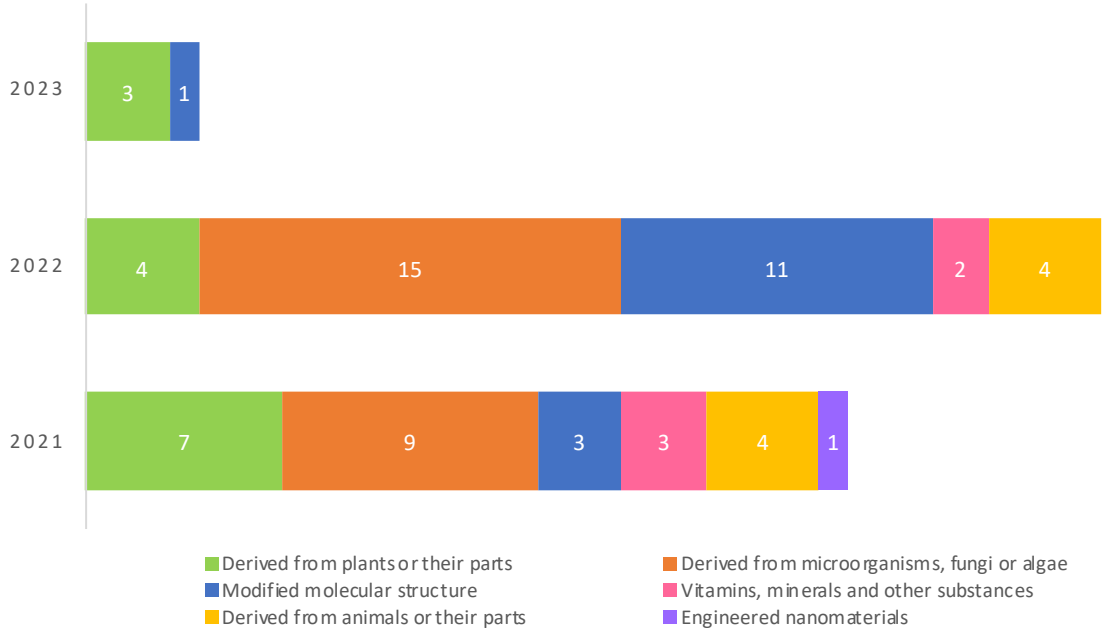
Novel foods mandates - collection and categorisation

Fifty-four NF mandates met the inclusion criteria (described in phase one). Mandates and respective scientific opinions retrieved from this search are provided in Annex B together with their respective categorisation. A summary of the results is reported in Figure 2. A NF may fall under one or more categories. In the latter case, the NF was assigned a double categorisation accordingly (see Annex B). Over the period studied, the highest number of outputs was observed for the following categories: "derived from microorganisms, fungi or algae" (n=24); "modified molecular structure" (n =15); "derived from plants or their parts" (n=14); and "derived from

[7] https://www.efsa.europa.eu/sites/default/files/documents/legal/dp/dp-COM5.pdf.
[8] Previously twitter. https://twitter.com/

animals or their parts" (n=8). Five scientific opinions were published for the NF category "Vitamins, minerals, and other substances" in 2021 and 2022, and one for "Engineered nanomaterials" in 2021. No NF opinions were published in the analysed timeframe for the following categories: "Mineral origin", "Derived from cell or tissue culture", "Derived from novel production process", and "Foods other than food supplements".

Figure 2 *- Number of NF outputs published per year (1 January 2021-8 May 2023) and per category for mandates received by EFSA falling under Regulation (EU) 2015/2283*



Societal insights in risk communication

Phase One: mandates assessment of novel foods

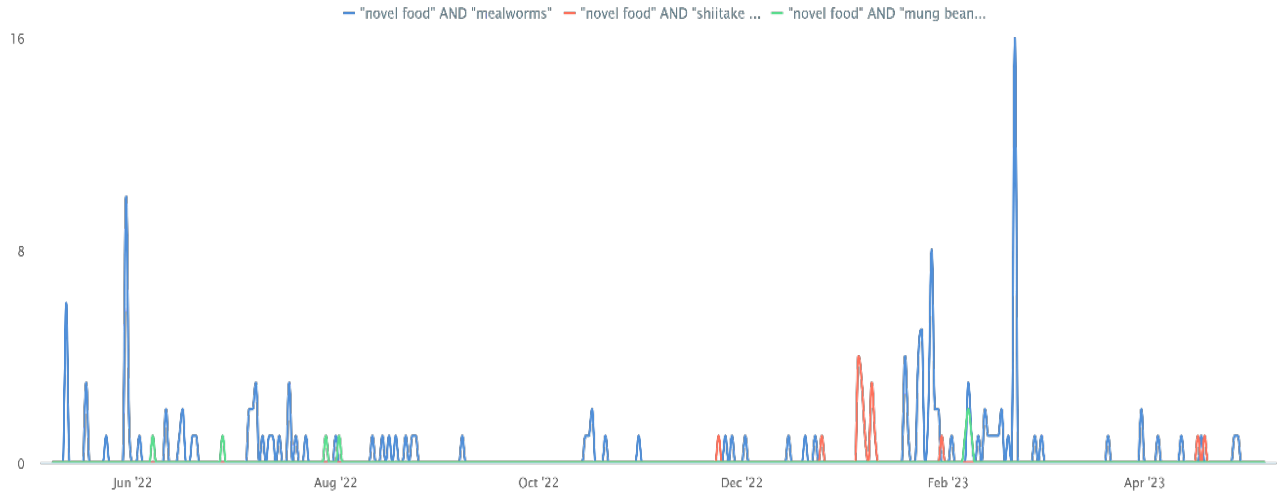
Mandates assessment

Based on our evaluation of scientific risk assessments related to NFs using the 20-criteria checklist (Table 1), we found that for all retrieved NFs (Annex B), the specific topic related to a NF had not been previously evaluated by EFSA (criterion 5 was met), and the authorisation of these NFs for entry into the EU market could have a market impact (criterion 20 was met).

In addition, we used a social media monitoring tool[9] to perform an analysis for criterion 9. Figure 3 shows an example from a one-year timeframe on the x-axis, from 8 May 2022 to 8 May 2023. The y-axis indicates the number of posts collected on that date; for instance, the highest peak with sixteen social media posts was reached on 21 February 2023 for mealworms. This analysis revealed that the specific topic of only thirteen NFs across four categories (i.e., "derived from microorganisms, fungi or algae", "modified molecular structure", "derived from plants or their parts", and "derived from animals or their parts") was prominent in social media (criterion 9 was met). Based on these findings, risk communication is recommended for these thirteen NFs, listed in Table 2 along with their respective NF categorisation, as they met three criteria (i.e., 5, 9, and 20).

[9] i.e., https://www.efsa.europa.eu/sites/default/files/documents/legal/dp/dp-COM5.pdf

Figure 3 – An example search in one-year timeframe (8 May 2022-8 May 2023) performed for "mealworms", "shiitake", and "mung bean" as NFs on the social media listening tool to check the social media volume of NF mandates



In summary, our analysis of published NF assessments by EFSA in phase one revealed that, regardless of their category, NFs are a sensitive topic due to institutional and stakeholder interests. However, NFs in the categories of "modified molecular structure", "derived from microorganisms, fungi or algae", "derived from plants or their parts", and "derived from animals or their parts" had a relatively high level of social media activity compared to other categories. These indications guided our investigation into the factors behind this activity, to inform potential risk communication strategies.

It is important to note that although EFSA did not publish any scientific opinions on NFs "derived from cell or tissue culture" during the timeframe of our analysis, this category of NFs generated significant interest on social media in terms of the number of posts and engagement. This indicates a high level of societal interest in this category of NFs.

Intermediate phase: Shared features triggering societal interest

To identify potential technical and/or scientific similarities across NFs belonging to the same category that may be responsible for triggering social media prominence, we examined the content of the thirteen NF scientific opinions listed in Table 2.

Modified molecular structure + Derived from microorganisms, fungi or algae

Lacto-N-neotetraose (EFSA NDA Panel, 2022a) and Lacto-N-tetraose (EFSA NDA Panel, 2022b) are categorised as "Modified molecular structure" and "Derived from microorganisms, fungi or algae" NFs. They are human identical milk oligosaccharides (i.e., identical in structure to oligosaccharides naturally present in breast milk) produced through fermentation with engineered microbial cell factories, i.e., genetically modified strains of *E. coli* K-12 BL21, and BL21 (DE3), respectively. The EFSA Panel on Nutrition, Novel Foods and Food Allergens (NDA Panel) concluded that they are safe for human consumption under the proposed conditions of use, as they are chemically and structurally identical to human milk oligosaccharides and do not contain viable cells, DNA, or toxicologically relevant effects.

These NFs share similar production processes, which are referred to as precision fermentation in the context of this publication.[10] Additionally, both Lacto-N-neotetraose and Lacto-N-tetraose are intended for uses in infant formula. These factors could have contributed to societal interest, but precision fermentation is the aspect that sets them apart as NFs. Therefore, precision fermentation was a key aspect investigated in phase two.

[10] https://www.efsa.europa.eu/en/events/efsas-scientific-colloquium-27-cell-culture-derived-foods-and-food-ingredients

Table 2 - List of NF mandates holding three criteria according to the EFSA checklist (Table 1) and selected for their relatively high social media prominence

Mandates	NF Category	Reference to the scientific opinion
Request for a scientific opinion on Lacto-N-neotetraose as a novel food (NF 2019/1359)	• Modified molecular structure • Derived from microorganisms, fungi or algae	(EFSA NDA Panel, 2022a)
Request for a scientific opinion on Lacto-N-tetraose (LNT) as a novel food (NF 2020/1809)		(EFSA NDA Panel, 2022b)
Request for a scientific opinion on Yarrowia lipolytica yeast biomass as a novel food (NF 2020/1950)	• Derived from microorganisms, fungi or algae	(EFSA NDA Panel, 2022c)
Request for a scientific opinion on pea and rice protein fermented by Shiitake mushroom (Lentinula edodes) mycelia as a novel food (NF 2019/1459)		(EFSA NDA Panel, 2022d)
Request for a scientific opinion on Galacto-oligosaccharide as a novel food (NF 2020/1607)		(EFSA NDA Panel, 2021b)
Request for a scientific opinion on dried mealworms (Tenebrio molitor) as a novel food (NF 2018/0241).	• Derived from animals or their parts	(EFSA NDA Panel, 2021c)
Request for a scientific opinion on whole and ground grasshoppers (Locusta migratoria) as a novel food (NF 2018/0803).		(EFSA NDA Panel, 2021d)
Request for a scientific opinion on whole and ground crickets (Acheta domesticus) as a novel food (NF 2018/0804).		(EFSA NDA Panel, 2021e)
Request for a scientific opinion on whole and ground mealworms (Tenebrio molitor) larvae as a novel food (NF 2018/0802).		(EFSA NDA Panel, 2021f)
Request for a scientific opinion on defatted whole cricket (Acheta domesticus) powder as a novel food (NF 2019/1227)		(EFSA NDA Panel, 2022e)
Request for a scientific opinion on frozen and freeze-dried formulations of the lesser mealworm (Alphitobius diaperinus larva) as a novel food (NF 2018/0125)		(EFSA NDA Panel, 2022f)
Request for a scientific opinion on mung bean protein as a novel food (NF 2020/1651)	• Derived from plants or their parts	(EFSA NDA Panel, 2021g)
Request for a scientific opinion on whole seeds of oilseed rape as a novel food (NF 2018/0590).		(EFSA NDA Panel, 2023)

Derived from microorganisms, fungi or algae

Dried and heat-killed biomass of *Yarrowia lipolytica* is a NF derived from microorganisms. In 2019, the NDA Panel had already concluded that the NF was safe (EFSA NDA Panel, 2019). Hence, when in 2022, EFSA assessed the request for its extension of use as a food ingredient in single meal replacement products for weight reduction, no toxicological studies were required. No other concerns arose from its composition or nutritional assessment (EFSA NDA Panel, 2022c). It was therefore concluded that *Yarrowia lipolytica* yeast biomass was safe under the extended proposed conditions of use.

Similarly, the risk assessment of pea and rice protein fermented by Shiitake (*Lentinula edodes*) mycelia (EFSA NDA Panel, 2022d) did not raise safety concerns, and no toxicological studies were required given the history of safe use of the individual components. Microorganisms were used in the production process to improve the organoleptic properties of plant proteins. Neither the presence of contaminants nor the nutritional profile

raised safety concerns. Potential sensitisation of individuals or induction of allergic reactions in individuals allergic to pea, rice and Shiitake mushrooms could not be excluded but did not raise safety concerns, and no toxicological studies were required given the history of safe use of the individual components.

Galacto-oligosaccharides (GOS) produced enzymatically by two β-galactosidases had previously been authorised for the EU market to be used as food ingredients, infant and follow-on formulae, baby foods and food supplements[11] as replacements for sugars. In 2021, EFSA assessed the change in their conditions of use with a proposed new use level increasing that previously authorised for use in food supplements (EFSA NDA Panel, 2021b). The NDA Panel concluded that the proposed changes did not raise safety concerns.

No common element could be established across these NFs in the "derived from microorganisms, fungi or algae" category to explain why they could have triggered public discourse, besides the fact that they are derived from microorganisms.

Derived from animals or their parts

Out of eight NFs in the "derived from animals or their parts" category assessed by EFSA, six were insect-derived. Specifically, these NFs were derived from lesser mealworm (*Alphitobius diaperinus* larva) (EFSA NDA Panel, 2022f), house cricket (*Acheta domesticus*) (EFSA NDA Panel, 2021e; EFSA NDA Panel, 2022e), yellow mealworm (T*enebrio molitor* larva) (EFSA NDA Panel, 2021c; EFSA NDA Panel, 2021f), and migratory locust (*Locusta migratoria*) (EFSA NDA Panel, 2021d), and were proposed for use as whole foods (i.e., the whole insect) and/or as food ingredients in diverse food products. Their allergenicity potential was consistently indicated in all six scientific opinions. Due to the cross-reactivity of the insects' proteins to other allergens, these NFs might induce allergic reactions in individuals who are allergic to crustaceans, mites, and molluscs. Moreover, insect proteins might trigger allergic reactions due to primary sensitisation, and the presence of allergens from the animal feed could not be excluded. Allergenicity apart, the NDA Panel concluded that all these insect-derived NFs were safe under the proposed conditions of use.

All six insect-derived NFs resulted in a recommended risk communication in phase one, and the nature of their source (i.e., insect) was considered a key factor in the relatively high level of engagement on social media.

Derived from plants or their parts

Mung bean protein is a NF in the "derived from plants or their parts" category. It is extracted from seeds of the *Vigna radiata* plant and was proposed for use as a food ingredient in protein products. Considering the composition of the NF and the proposed conditions of use, the NDA Panel concluded that consumption of the NF was not nutritionally disadvantageous, and while caution was warranted due to its potential to cause allergic reactions in individuals allergic to legumes and birch pollen, it was deemed safe for consumption under the proposed conditions of use (EFSA NDA Panel, 2021g).

Whole seeds of oilseed rape (*Brassica napus* L emend. Metzg.) were proposed as a food ingredient in bread and rolls and gluten-free bread (EFSA NDA Panel, 2023). For this NF, the NDA Panel could not establish their safety because of the significant presence of antinutrients, which would lead to the consumption of high levels of glucosinolates (EFSA NDA Panel, 2023).

No common elements that could have triggered public discourse, besides the category itself, could be established across NFs "derived from plants or their parts".

Overall, the screening of NFs identified in phase one revealed that production processes involving precision fermentation were a distinguishing factor for NFs categorised as "Modified molecular structure + Derived

[11] Commission Implementing Regulation (EU) 2017/2470 of 20 December 2017 establishing the Union list of novel foods in accordance with Regulation (EU) 2015/2283 of the European Parliament and of the Council on novel foods. OJ L 351, 30.12.2017, p. 72–201.

from microorganisms, fungi, or algae". Similarly, insects as source material were identified as the key factor of the significant engagement on social media within the category of NFs "derived from animals or their parts". Therefore, precision fermentation and insect-derived foods were further investigated within their respective categories.

On the other hand, no common element generating relatively high volumes of social media discourse could be established across NFs "derived from microorganisms, fungi or algae" alone and "derived from plants or their parts", apart from the category itself.

This underscores that while it may be possible to develop a risk communication strategy based solely on a NF category, there are cases where it is essential to comprehensively screen the specific and technical features that could affect the public interest. This approach is necessary to avoid over-generalising communication approaches.

Phase Two: Appraisal phase

After analysing the results from phase one and the intermediate phase, in phase two we investigated NFs in general and focused only on the following NF categories and aspects:

- Derived from microorganisms, fungi or algae
- Derived from plants or their parts
- Derived from animals or their parts based on insect-derived foods
- Modified molecular structure based on precision fermentation
- Derived from cell or tissue culture.

Social Research Data

Our scientific literature search resulted in twenty-eight relevant papers, out of which ten were literature reviews and eighteen were experimental research papers (Annex C).

Sociological research data on NF technologies (Siegrist and Hartmann, 2020a; Siddiqui et al., 2022) show that consumers' acceptance is influenced by two main factors: the characteristics of the food technology, i.e., if it is perceived as natural, under one's control, not dreaded, and exposure is perceived as voluntary; and the individual's characteristics, such as disgust sensitivity, food technology neophobia, and cultural values. These factors have an impact on the heuristics that consumers adopt, specifically "affect heuristic", "natural-is-better heuristic", and "trust heuristic" (for a definition of these heuristics see Siegrist and Hartmann, 2020a).

On the one hand, aspects like nutritional quality, novelty effect, low price, environmental impact, sustainability, and animal welfare could trigger consumers' interest in NFs, particularly in alternative proteins. Health reasons, rather than sustainability, environmental, or animal welfare concerns, are the most influential motivations for trying NFs. On the other hand, the sensory appeal, high price, and perceptions about the safety of NFs are barriers that prevent consumers from accepting these products (Tso et al., 2020). Perceptions vary, based on the type of NF. For example, for alternative proteins, consumers' perception and acceptance of plant-based proteins (including legumes and pulses) is more positive than for insect-based and cell culture-derived NFs, which are seen as less positive and the least accepted (Faber et al., 2021; Onwezen et al., 2021; Possidónio et al., 2021; Siegrist and Hartmann, 2023).

European consumers' perception and acceptance of insect-based meat alternatives have received extensive attention in the social science literature in recent years. Research shows that human consumption of insects, i.e., entomophagy, is influenced by a variety of factors. In particular, food neophobia and disgust are the most influential psychological barriers affecting the willingness to try insects (Verbeke, 2015; Tan et al., 2016; de Koning et al., 2020; Ardoin and Prinyawiwatkul, 2021). On the other hand, more neophilic individuals, younger generations, and people who have already heard of entomophagy or eaten insects in their life are more open

to adopting insects as meat substitutes (Hartmann and Siegrist, 2016; Wendin and Nyberg, 2021; Caparros Megido et al., 2016). The degree of processing can have an impact on acceptance, as studies have shown that the less recognisable insects are, e.g., presented as flour or as ingredients in burgers instead of whole, the more positive reactions are reported by study participants (Gmuer et al., 2016). A recent study has shown that the use of attractive packaging can also influence consumers' acceptance of insect-based food, pointing out that abstract or stylistic representations of insects are less repulsive than realistic images (Marquis et al., 2023).

Another alternative protein that has been researched from a social science standpoint is cell culture-derived meat. A study conducted in Belgium, Portugal, and the United Kingdom (Verbeke et al., 2015a) showed that the perception of potential personal and societal risks outweighs the perceived benefits, as these are believed to affect global society rather than the individual, meaning that they are seen as distant. In terms of social risks, consumers are concerned about the loss of culinary traditions, rural livelihood, and the preservation of livestock. A cross-country study revealed that there are cultural differences in acceptance, with lower levels in countries like France and higher levels in countries like Mexico, South Africa, and the United Kingdom (Siegrist and Hartmann, 2020b).

Other barriers that affect the consumption of cell culture-derived meat are repulsion/disgust, the so-called "yuck factor" or the perception of unnaturalness and the unknown. It is also linked to consumers' uncertainty about safety issues, e.g., nutritional deficiencies, potential adverse effects, and long-term health consequences (Verbeke et al., 2015b; Tomiyama et al., 2020; Wilks et al., 2021). Factors facilitating acceptance are high concern for the environment and animal welfare, as well as previous consumption of meat substitutes.

Some research in the United States explored the impact of the name used to refer to cell culture-derived meat on acceptance and found that "lab-grown meat", "animal-free meat", and "cultured meat" were perceived as negative due to associations with artificialness and unnaturalness, whereas the term "clean meat" was perceived as positive, associated with healthiness and tastiness (Bryant and Barnett, 2019). In terms of frames, more technical frames were perceived negatively, while frames focusing on the societal benefits and presenting the product as "same meat" were perceived more positively (Bryant and Dillard, 2019).

Few recent papers have focused on NFs produced by precision fermentation (Broad et al., 2022, Banovic and Grunert, 2023). Broad et al. (2022) investigated consumer perceptions of "animal-free dairy" during a virtual focus group of potential "early adopters" of alternatives to animal dairy from Germany, United Kingdom, United States, and Singapore. The study revealed concerns about the potential health risks to humans. The authors concluded that consumers' acceptance of "animal-free dairy" products will probably increase if advantages related to the safety of these products, sensorial characteristics and nutrition, along with environmental effects and animal welfare, can be clearly demonstrated compared to conventional alternatives. A quantitative study on a representative sample of the Danish, German, and Polish populations confirmed the qualitative findings, showing that framing this technology as natural and similar to traditional fermentation increased acceptance, trust levels, and perceived benefits (Banovic and Grunert, 2023).

Research on perceptions of microorganisms, fungi, and algae is still in the early stages. One study (Van der Stricht et al., 2023) assessed consumers' willingness to buy food made with microalgae proteins in five EU countries (Germany, Hungary, Italy, Spain, and the Netherlands). Results showed that willingness to pay was affected by the product label; it was the highest for organic labels, followed by labels indicating that it was healthy and nutritious, and it was lowest for a vegan label. It is noteworthy that one in six respondents decided to opt out of choosing a product made with microalgae due to high cost or lack of familiarity or sensory appeal.

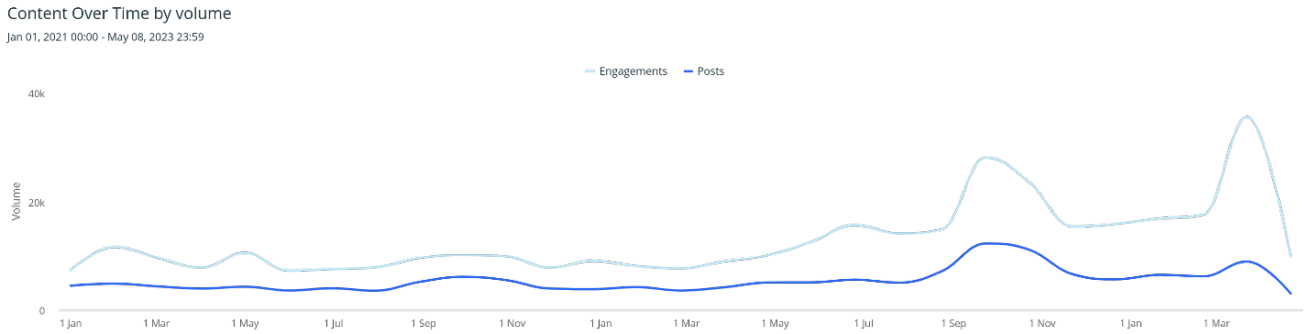
Finally, NFs "derived from plants or their parts" have been studied when comparing perceptions of insect-

based versus cell culture-derived versus plant-based proteins. A recent review (Siegrist and Hartmann, 2023) providing an overview of perceptions and acceptance of these alternative proteins in Western countries showed that plant-based proteins are perceived as healthy and acceptance as meat replacement is high. By contrast, insect-based and cell-culture-derived proteins are perceived as unhealthy, and acceptance as meat replacement is low.

Public discourse

The social media discourse on NFs was tracked through 429K posts spread across the selected timeframe i.e., 1 January, 2021 - 8 May 2023 (Figure 4).

Figure 4 - Overview of social media on NFs, 1 January, 2021 to 8 May, 2023, with indication of number of posts and engagement level (i.e., likes, shares) in the period 1 January, 2021 to 8 May 2023



Such results refer to the discourse about NFs in general. Table 3 presents an overview of the metrics for NFs and each NF category separately, along with a summary of the peaks in their volume of discussion.

Table 3 - Overview of the metrics for NFs in general and each category separately, including an overview of the peaks in volume

	Novel foods based on alternative proteins	**Of which Derived from animals or their parts based on insect-derived foods**	**Of which Derived from microorganisms, fungi or algae**	**Of which Modified molecular structure based on precision fermentation**	**Of which Derived from plants or their parts**	**Of which Derived from cell or tissue culture**
Volume (posts)	429K	4K	1.7K	329	10K	57K
Sentiment (-50 to 50)	3.2	-5	3.8	11	5	-2.8
Peaks (number of posts)/ topic	March-April 2023 (37K)/ cell-culture-derived food	July-August 2022 (647)/three insects approved as novel food in the EU	August-September2022 (137)/ new research studies on algae	June-July 2022 (22)/discourse related to precision fermentation applied to plants and fungi	July-August 2022 (552)/ discussions on banning the use of names like "steak" for plant-based protein products	April-May 2023 (12K)/ discussions around ban

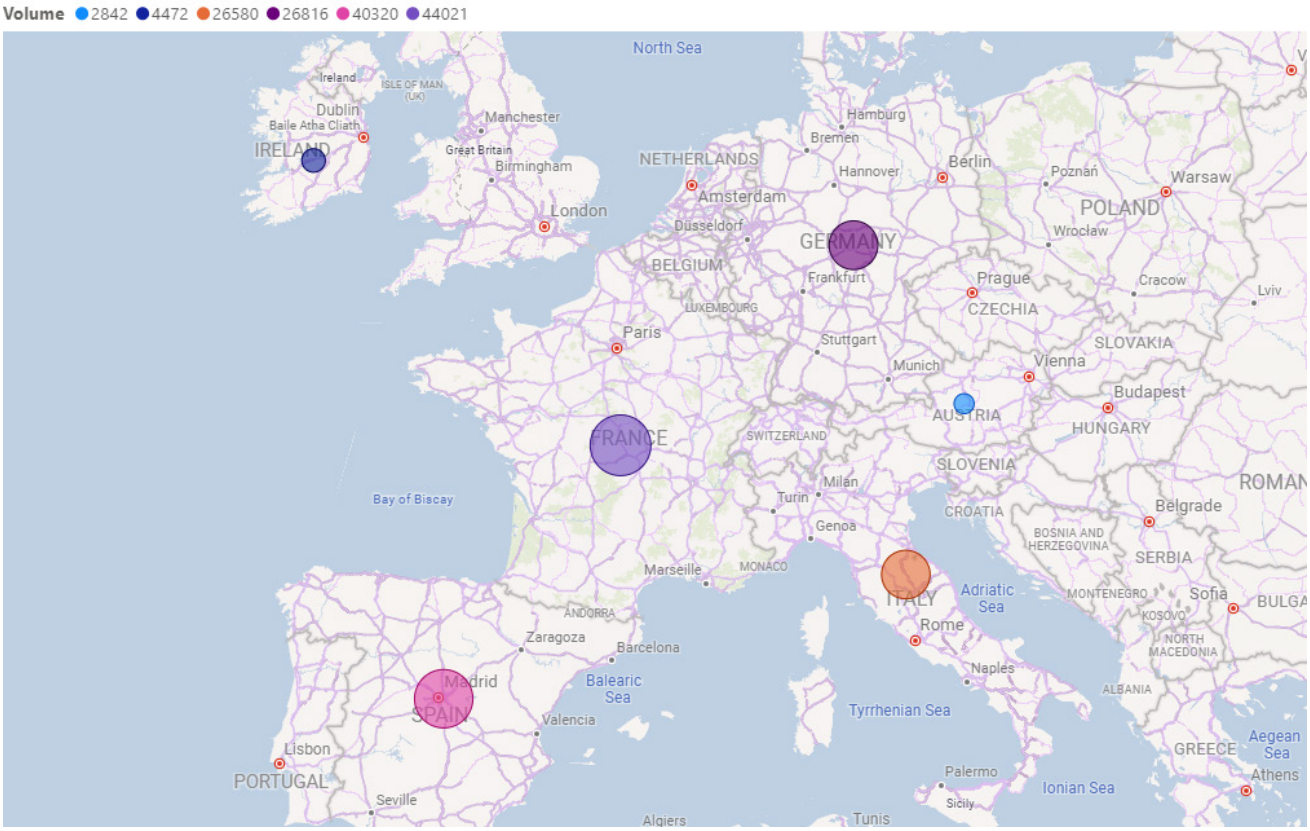
In the area of NFs as alternative proteins, among the NF categories with the highest social media prominence, cell culture-derived food was the most discussed, with a social media volume of 57K out of 429K of the total social media posts on NFs. The least discussed NF category was "Modified molecular structure" with only

329 posts identified.

Overall, the sentiment was neutral across the EU, independently of the NF category, i.e., scores included between -14/+14 scores. Nonetheless, NFs "Derived from animals or their parts" and "Derived from cell or tissue culture" were the only two categories with a sentiment scoring below 0 (i.e., -5 and -2.8 respectively). Notably, the NF category with the lowest social media volume (i.e., "Modified molecular structure"), showed the highest sentiment score, with a 11.

For the analysis of the geographical distribution of the discourse in the period 1 January 2021 to 8 May 2023, we focused on countries where English, French, German, Italian, and Spanish are predominantly spoken, given that the keywords in the query were translated into these languages. The top countries talking about NFs were France (30.4%), followed by Spain (27.9%), Germany (18.5%) and Italy (18.4%). The social media discourse on NFs was the lowest in Ireland (2.8%) and Austria (1.8%) (Figure 5).

Figure 5 - Differences in social media volume between European countries included in the analysis in the period 1 January 2021 to 8 May 2023



On the topic of insect-based NFs, Germany was the only country with more positive than negative discourse, whereas all other EU countries talked about them in either a neutral or a more negative than positive way. Furthermore, the sentiment for cell culture-derived foods was more positive than negative in Austria, France, Ireland, and Germany (average of 36% positive vs 25% negative and 39% neutral). On the other hand, it was more negative than positive for Spain (33% negative vs 16% positive and 51% neutral) and Italy (30% negative vs 20% positive and 50% neutral). No geographical differences were noted for all the other NF categories, for which the discourse was neutral throughout all the countries included.

Such differences in terms both of engagement and of sentiment may be due to cultural diversity, as also indicated in the publicly available literature. Hence, the overall 'neutral' perception of NFs and their categories may also be associated with a polarised discussion.

Risk communication advice

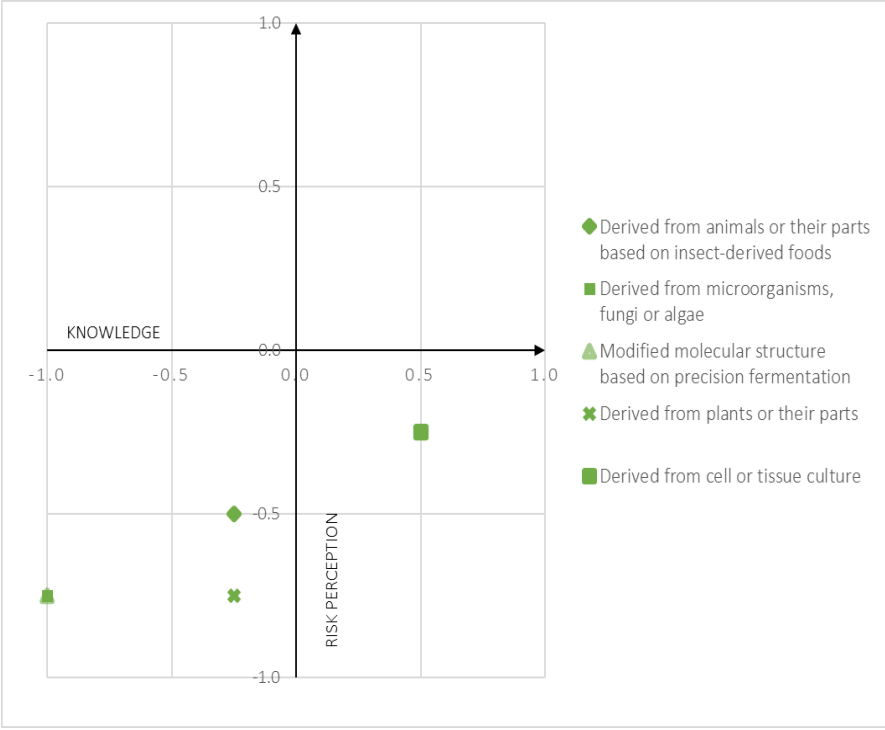
Based on the analysis of secondary social research data and primary social media discourse data, we assigned a value of -1 (low), 0 (medium) or 1 (high) to each component of knowledge and risk perception for each NF category (Table 4).

Table 4 - Overview of assigned values for each NF category and the average for knowledge and perception

	Derived from animals or their parts based on insect-derived foods	Derived from micro-organisms, fungi or algae	Modified molecular structure based on precision fermentation	Derived from plants or their parts	Derived from cell or tissue culture
Self-reported awareness	0	-1	-1	0	1
Self-reported knowledge	0	-1	-1	0	1
Objective knowledge	0	-1	-1	0	0
Social media volume	-1	-1	-1	-1	0
KNOWLEDGE	**-0.25**	**-1**	**-1**	**-0.25**	**0.50**
Self-reported concern	0	-1	-1	-1	1
Self-reported importance	-1	-1	-1	-1	-1
Self-reported interest	-1	-1	-1	-1	-1
Social media sentiment	0	0	0	0	0
RISK PERCEPTION	**-0.50**	**-0.75**	**-0.75**	**-0.75**	**-0.25**

The intersection between knowledge and risk perception results in a four-quadrant system displayed in Figure 6. The categories "Derived from animals or their parts", "Derived from microorganisms, fungi or algae", "Modified molecular structure", and "Derived from plants or their parts" fall in the low-knowledge/low-risk perception quadrant, while cell culture-derived food falls in the high-knowledge/low-risk perception quadrant.

Figure 6 - Representation of the position of each NF category in the knowledge-risk perception plot



All the collected information allowed us to place NF categories on the knowledge-risk perception plot

and analyse them from a risk communication standpoint. Out of the four risk communication objectives (EFSA 2021; Renn, 2009; Vrbos et al., 2023), "enlightenment" is deemed most appropriate for the categories in the low knowledge/low risk perception quadrant (i.e., "Derived from animals or their parts" based on insect-derived foods, "Derived from microorganisms, fungi or algae", "Modified molecular structure" based on precision fermentation, and "Derived from plants or their parts" NF categories). On the other hand, "confidence-building" and "cooperative decision-making" are the most appropriate for the high knowledge/low risk perception quadrant (i.e., NFs derived from cell or tissue culture).

The "enlightenment" objective aims at enhancing the individual's understanding and knowledge of risks through awareness raising or presentation of risk assessment findings. As an example, when EFSA published a series of scientific opinions on NFs, including the first completed assessment of a proposed insect-derived food product, the "news story" presented the assessment findings while acknowledging public perceptions and potential societal concerns derived from social and cultural experiences (i.e., the "yuck factor").[12]

The "confidence-building" objective aims at establishing or enhancing trustful relationships between the sender and the receiver of the communication while the "cooperative decision-making" objective involves stakeholders in resolving existing or potential differences in views on the matter. As an example, EFSA published a "news story" on the safety of cell culture-derived foods, providing insights from experts in this field to illustrate some of the scientific issues involved and the social and economic backdrop.[13] This was done to highlight EFSA's readiness to evaluate these potential NFs and to gather views and insights on the latest scientific and technical developments in the field. Furthermore, as regards these communication objectives, EFSA organised a scientific colloquium in May 2023 to: identify sectors in the agri-food sector relevant to potential cell culture-derived foods of animal or plant origin and food ingredients produced through precision fermentation; review the state-of-the-art of relevant concepts, technologies, and derived products; and discuss emerging safety and methodological aspects and their impact on EFSA's risk assessment approaches.[14]

Conclusions

One crucial objective of risk communication is to take account of societal knowledge and risk perception of NFs for effectively informing all interested parties of risk assessment outcomes. While it may be tempting to design a risk communication strategy based solely on the category of the NF, our analysis shows the importance of thoroughly screening the scientific features that may affect the public interest, to ensure that communication approaches are tailored to NFs that possess shared characteristics and risks. Our research indicates that NFs derived from microorganisms, fungi, or algae, produced with precision fermentation, and derived from insects and plants, resulted in low-knowledge/low-risk perception. Therefore, risk communication approaches should aim to enhance individuals' understanding and knowledge of risks through awareness-raising. For cell culture-derived foods, where public knowledge is greater, communication approaches should aim to resolve existing or potential differences in views on the matter and to establish or enhance trustful relationships between the sender and the receiver of the communication. By tailoring risk communication strategies to the technical features, societal knowledge and risk perception of NF, all interested parties can be effectively informed of the risk assessment outcomes.

Future perspectives

Based on the experience built on NFs assessed by EFSA in the past three years, it is important to establish and promote a continuous dialogue with stakeholders, aimed at understanding levels of knowledge and perceptions towards NFs. This will enable the design of tailored risk communication approaches. In this regard, proactively seeking and providing information on the most recent scientific and technological developments

[12] https://www.efsa.europa.eu/en/news/edible-insects-science-novel-food-evaluations
[13] https://www.efsa.europa.eu/en/news/safety-cell-culture-derived-food-ready-scientific-evaluation
[14] https://www.efsa.europa.eu/en/events/efsas-scientific-colloquium-27-cell-culture-derived-foods-and-food-ingredients

should be considered, especially for NFs that are expected to become increasingly important in the coming years and of public interest (e.g., "precision fermentation" and cell culture-derived foods and ingredients). It is worth noting that the present research focused on social media data that provide a limited picture of public knowledge and risk perceptions. Future studies should include primary data collected through surveys targeting representative samples of the EU population, to help ensure that results can be applied more broadly and to more diverse audiences in terms of socio-demographic characteristics. Importantly, the findings show that a tailored approach is needed and future communication on NFs by EFSA needs to take NF categories into account and to develop ad-hoc messages addressing citizens' knowledge and perceptions. Ultimately, this approach would contribute to fostering a social environment where stakeholders are aware of the risk assessment outcomes and prepared to make informed decisions about NFs.

Disclaimer

The authors Giorgia Zamariola, Domagoj Vrbos, and Anthony Smith are employed with the European Food Safety Authority (EFSA) in the Communication Unit. The authors Andrea Germini, Maria Glymenaki (trainee from November 2022 to November 2023), Marcello Laganaro, Vânia Mendes (trainee from November 2022 to November 2023), Alejandra Muñoz González (trainee from October 2022 to October 2023), Irene Nuin Garciarena, Gabriela Precup, Ruth Roldán-Torres, and Ermolaos Ververis are employed with the European Food Safety Authority (EFSA) in the Nutrition and Food Innovation Unit that provides scientific and administrative support to the Panel on Nutrition, Novel Foods and Food Allergens in the area "Safety Assessment of Novel Foods". Likewise, the author Esther Garcia Ruiz is currently employed by Randstad (c/o EFSA) in the same EFSA Unit. However, the views expressed in this publication are those of the authors and should not be interpreted as representing the official position of the European Food Safety Authority (EFSA). Therefore, the present article is published under the sole responsibility of the authors, and may not be considered as an EFSA scientific output. EFSA cannot be held accountable for any errors or inaccuracies that may appear.

To know about the views or scientific outputs of EFSA, please consult its website at http://efsa.europa.eu/. Note to the reader: The information provided in this manuscript refers to the activities of EFSA in the area of Novel Foods up to 8 May 2023. Future risk assessments of NFs by EFSA will be available on the OpenEFSA portal at the following link: https://open.efsa.europa.eu/.

Abbreviations

DNA	Deoxyribonucleic acid
EC	European Commission
EFSA	European Food Safety Authority
EU	European Union
GOS	Galacto-oligosaccharides
IRGC	International Risk Governance Center
NDA Panel	EFSA Panel on Nutrition, Novel Foods and Food Allergens
NF	Novel Food

References

Ardoin R and Prinyawiwatkul W. (2021) Consumer perceptions of insect consumption: a review of western research since 2015. *International Journal of Food Science & Technology* 56: 4942-4958.

Banovic M and Grunert KG. (2023) Consumer acceptance of precision fermentation technology: A cross-cultural study. *Innovative Food Science & Emerging Technologies* 88.

Boehm, E., Borzekowski, D., Ververis, E., Lohmann, M., & Böl, G. F. (2021). Communicating food risk-benefit assessments: edible insects as red meat replacers. Frontiers in Nutrition, 8, 749696.

Broad GM, Zollman Thomas O, Dillard C, et al. (2022) Framing the futures of animal-free dairy: Using focus groups to explore early-adopter perceptions of the precision fermentation process. *Frontiers in Nutrition* 9.

Bryant C and Dillard C. (2019) The Impact of Framing on Acceptance of Cultured Meat. *Frontiers in Nutrition* 6.

Bryant CJ and Barnett JC. (2019) What's in a name? Consumer perceptions of in vitro meat under different names. *Appetite* 137: 104-113.

Camarena DM, Sanjuán AI and Philippidis G. (2011) Influence of ethnocentrism and neo-phobia on ethnic food consumption in Spain. *Appetite* 57: 121-130.

Caparros Megido R, Gierts C, Blecker C, et al. (2016) Consumer acceptance of insect-based alternative meat products in Western countries. *Food Quality and Preference* 52: 237-243.

Codex Alimentarius (2003) Working Principles for Risk Analysis for Application in the Framework of the Codex Alimentarius - Section III. Codex Alimentarius Commission, Joint FAO/WHO Food Standards Programme, Rome

de Koning W, Dean D, Vriesekoop F, et al. (2020) Drivers and Inhibitors in the Acceptance of Meat Alternatives: The Case of Plant and Insect-Based Proteins. *Foods* 9.

Donadini G, Spigno G and Porretta S. (2021) Preschooler liking of meal components: The impact of familiarity, neophobia, and sensory characteristics. *Journal of Sensory Studies* 36.

EFSA. (2021). Technical assistance in the field of risk communication. EFSA Journal, 19(4), e06574.

EFSA NDA Panel (2019). Scientific Opinion on the safety of Yarrowia lipolytica yeast biomass as a novel food pursuant to Regulation (EU) 2015/2283. EFSA Journal 2019;17(2):5594, 12 pp. https://doi.org/10.2903/j.efsa.2019.5594. *EFSA Journal* 17

EFSA NDA Panel. (2021a) Guidance on the preparation and submission of an application for authorisation of a novel food in the context of Regulation (EU) 2015/2283 (Revision 1)(2). *EFSA Journal* 19: e06555.

EFSA NDA Panel. (2021b) Safety of a change in the conditions of use of galacto-oligosaccharides as a novel food ingredient in food supplements pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 19.

EFSA NDA Panel. (2021c) Safety of dried yellow mealworm (Tenebrio molitor larva) as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 19.

EFSA NDA Panel. (2021d) Safety of frozen and dried formulations from migratory locust (Locusta migratoria) as a Novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 19.

EFSA NDA Panel. (2021e) Safety of frozen and dried formulations from whole house crickets (Acheta domesticus) as a Novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 19.

EFSA NDA Panel. (2021f) Safety of frozen and dried formulations from whole yellow mealworm (Tenebrio molitor larva) as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 19.

EFSA NDA Panel. (2021g) Safety of mung bean protein as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA J* 19: e06846.

EFSA NDA Panel. (2022a) Safety of the extension of use of 2'-fucosyllactose (2'-FL) and lacto-N-neotetraose (LNnT) as novel foods in food supplements for infants pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2022b) Safety of lacto-N-tetraose (LNT) produced by derivative strains of Escherichia coli BL21 (DE3) as a Novel Food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2022c) Safety of an extension of use of Yarrowia lipolytica yeast biomass as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2022d) Safety of pea and rice protein fermented by Shiitake (Lentinula edodes) mycelia as a Novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2022e) Safety of partially defatted house cricket (Acheta domesticus) powder as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2022f) Safety of frozen and freeze-dried formulations of the lesser mealworm (Alphitobius diaperinus larva) as a Novel food pursuant to Regulation (EU) 2015/2283. *EFSA Journal* 20.

EFSA NDA Panel. (2023) Safety of whole seeds of oilseed rape (Brassica napus L emend. Metzg.) as a novel food pursuant to Regulation (EU) 2015/2283. *EFSA J* 21: e07706.

EFSA Scientific Committee. (2022) Food safety in the EU. *Special Eurobarometer.*

Faber I, Henn K, Brugarolas M, et al. (2021) Relevant characteristics of food products based on alternative proteins according to European consumers. *Journal of the Science of Food and Agriculture* 102: 5034-5043.

Florin M and Bürkler MT. (2017) Introduction to the IRGC Risk Governance Framework. *EPFL International Risk Governance Center*.

Florin M and Parker S. (2020) Involving Stakeholders in the Risk Governance Process. *EPFL International Risk Governance Center*.

Gmuer A, Nuessli Guth J, Hartmann C, et al. (2016) Effects of the degree of processing of insect ingredients in snacks on expected emotional experiences and willingness to eat. *Food Quality and Preference* 54: 117-127.

Hartmann C and Siegrist M. (2016) Becoming an insectivore: Results of an experiment. *Food Quality and Preference* 51: 118-122.

Marquis D, Oliveira D, Pantin-Sohier G, et al. (2023) The taste of cuteness: How claims and cute visuals affect consumers' perception of insect-based foods. *International Journal of Gastronomy and Food Science* 32.

Onwezen MC, Bouwman EP, Reinders MJ, et al. (2021) A systematic review on consumer acceptance of alternative proteins: Pulses, algae, insects, plant-based meat alternatives, and cultured meat. *Appetite* 159.

Pliner P and Salvy SJ. (2006) Food neophobia in humans. *The psychology of food choice*. 75-92.

Possidónio C, Prada M, Graça J, et al. (2021) Consumer perceptions of conventional and alternative protein sources: A mixed-methods approach with meal and product framing. *Appetite* 156.

Renn O. (2009) Communication About Food Safety. *Food Safety Governance*. 121-141.

Rozin P and Vollmecke TA. (1986) Food Likes and Dislikes. *Annual Review of Nutrition* 6: 433-456.

Siddiqui SA, Zannou O, Karim I, et al. (2022) Avoiding Food Neophobia and Increasing Consumer Acceptance of New Food Trends—A Decade of Research. *Sustainability* 14.

Siegrist M and Hartmann C. (2020a) Consumer acceptance of novel food technologies. *Nature Food* 1: 343-350.

Siegrist M and Hartmann C. (2020b) Perceived naturalness, disgust, trust and food neophobia as predictors of cultured meat acceptance in ten countries. *Appetite* 155.

Siegrist M and Hartmann C. (2023) Why alternative proteins will not disrupt the meat industry. *Meat Science* 203.

Tan HSG, van den Berg E and Stieger M. (2016) The influence of product preparation, familiarity and individual traits on the consumer acceptance of insects as food. *Food Quality and Preference* 52: 222-231.

Tomiyama AJ, Kawecki NS, Rosenfeld DL, et al. (2020) Bridging the gap between the science of cultured meat and public perceptions. *Trends in Food Science & Technology* 104: 144-152.

Tso R, Lim AJ and Forde CG. (2020) A Critical Appraisal of the Evidence Supporting Consumer Motivations for Alternative Proteins. *Foods* 10.

Tuorila H and Hartmann C. (2020) Consumer responses to novel and unfamiliar foods. *Current Opinion in Food Science* 33: 1-8.

Van der Stricht H, Profeta A, Hung Y, et al. (2023) Consumers' willingness-to-buy pasta with microalgae proteins – Which label can promote sales? *Food Quality and Preference* 110.

Verbeke W. (2015) Profiling consumers who are ready to adopt insects as a meat substitute in a Western society. *Food Quality and Preference* 39: 147-155.

Verbeke W, Marcu A, Rutsaert P, et al. (2015a) 'Would you eat cultured meat?': Consumers' reactions and attitude formation in Belgium, Portugal and the United Kingdom. *Meat Science* 102: 49-58.

Verbeke W, Sans P and Van Loo EJ. (2015b) Challenges and prospects for consumer acceptance of cultured meat. *Journal of Integrative Agriculture* 14: 285-294.

Ververis, E., Ackerl, R., Azzollini, D., Colombo, P.A., de Sesmaisons, A., Dumas, C., et al. (2020). Novel foods in the European Union: Scientific requirements and challenges of the risk assessment process by the European Food Safety Authority. Food Research International, 137, 109515.

Vrbos D, Zamariola G, Maxim L, et al. (2023) Societal insights in risk communication planning – a structured approach. *Journal of Risk Research* 26: 841-854.

Wendin KME and Nyberg ME. (2021) Factors influencing consumer perception and acceptability of insect-based foods. *Current Opinion in Food Science* 40: 67-71.

Wilks M, Hornsey M and Bloom P. (2021) What does it mean to say that cultured meat is unnatural? *Appetite* 156.

Annex A

Social media query used for monitoring public discourse on novel foods.

(LOCATION (AT OR BE OR BG OR HR OR CY OR CZ OR DK OR EE OR FI OR FR OR DE OR GR OR HU OR IE OR IT OR LV OR LT OR LU OR MT OR NL OR PL OR PT OR RO OR SK OR SI OR ES OR SE)) AND ("novel food" OR "alternative proteins" OR "novel proteins" OR "meat substitutes" OR "meat alternatives" OR "plant-based proteins" OR "insect-based proteins" OR "edible insects" OR "cultured meat" OR "synthetic meat" OR "lab grown meat" OR "in vitro meat" OR "cell-based meat" OR "precision fermentation" OR (fungi OR algae AND food) OR "nuovi prodotti alimentari" OR "proteine alternative" OR "nuove proteine" OR "sostituti della carne" OR "alternative alla carne" OR "proteine vegetali" OR "proteine a base di insetti" OR "insetti commestibili" OR "carne coltivata" OR "carne sintetica" OR "carne da laboratorio" OR "carne in vitro" OR "carne a base di cellule" OR "fermentazione di precisione" OR (funghi OR alghe AND alimenti) OR "nouveaux aliments" OR "protéines alternatives" OR "nouvelles protéines" OR "substituts de viande" OR "alternatives à la viande" OR "protéines végétales" OR "protéines à base d'insectes" OR "insectes comestibles" OR "viande cultivée" OR "viande synthétique" OR "viande de laboratoire" OR "viande in vitro" OR "viande cellulaire" OR "fermentation de précision" OR (champignons OR algues AND aliments) OR "nuevos alimentos" OR "proteínas alternativas" OR "nuevas proteínas" OR "sustitutos de la carne" OR "alternativas a la carne" OR "proteínas vegetales" OR "proteínas basadas en insectos" OR "insectos comestibles" OR "carne cultivada" OR "carne sintética" OR "carne de laboratorio" OR "carne in vitro" OR "carne a base de células" OR "fermentación de precisión" OR (hongos OR algas AND alimentos) OR "neuartige Lebensmittel" OR "alternative Proteine" OR "neue Proteine" OR "Fleischersatz" OR "Fleischalternativen" OR "Proteine auf Pflanzenbasis" OR "Proteine auf Insektenbasis" OR "essbare Insekten" OR "kultiviertes Fleisch" OR "Laborfleisch" OR "synthetisches Fleisch" OR "im Labor gezüchtetes Fleisch" OR "In-vitro-Fleisch" OR "zellbasiertes Fleisch" OR "Präzisionsfermentation" OR (Pilze OR Algen AND Lebensmittel))

Annex B

Novel food mandates retrieved from OpenEFSA

Mandates	Date of publication of the Scientific Opinion	Scientific opinion	NF Category
Request for a scientific opinion on dried mealworms (Tenebrio molitor) as a novel food (NF 2018/0241)a	13/01/2021	https://doi.org/10.2903/j.efsa.2021.6343	Derived from animals or their parts
Request for a scientific opinion on Cistanche tubulosa extract as a novel food (NF 2019/1318)	18/01/2021	https://doi.org/10.2903/j.efsa.2021.6346	Derived from plants or their parts
Request for a scientific opinion on Schizochytrium sp. oil as a novel food (NF 2019/1046)	18/01/2021	https://doi.org/10.2903/j.efsa.2021.6345	Derived from microorganisms, fungi or algae
Request for a scientific opinion on Schizochytrium sp. oil as a novel food (NF 2019/0825).	13/01/2021	https://doi.org/10.2903/j.efsa.2021.6344	Derived from microorganisms, fungi or algae
Request for a scientific opinion on Galacto-oligosaccharide as a novel food (NF 2020/1607)[a]	27/01/2021	https://doi.org/10.2903/j.efsa.2021.6384	Derived from microorganisms, fungi or algae
Request for a scientific opinion on UV-treated mushrooms (Agaricus bisporus) as a novel food (NF 2019/1237)	08/04/2021	https://doi.org/10.2903/j.efsa.2021.6516	Derived from microorganisms, fungi or algae
Request for a scientific opinion on dried fruits of Synsepalum dulcificum as a novel food (NF 2018/0709)	11/06/2021	https://doi.org/10.2903/j.efsa.2021.6600	Derived from plants or their parts
Request for a scientific opinion on 3-fucosyllactose as a novel food (NF 2019/1321)	30/06/2021	https://doi.org/10.2903/j.efsa.2021.6662	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on Calcidiol as a novel food (NF 2018/0402)	01/07/2021	https://doi.org/10.2903/j.efsa.2021.6660	Vitamins, minerals and other substances
Request for a scientific opinion on UV-treated baker's yeast (Saccharomyces cerevisiae) as a novel food (NF 2020/1778)	01/07/2021	https://doi.org/10.2903/j.efsa.2021.6602	Derived from microorganisms, fungi or algae
Request for a scientific opinion on whole and ground grasshoppers (Locusta migratoria) as a novel food (NF 2018/0803)[a]	02/07/2021	https://doi.org/10.2903/j.efsa.2021.6667	Derived from animals or their parts
Request for a scientific opinion on Calcium Fructoborate as a novel food (NF 2019/0998)	05/07/2021	https://doi.org/10.2903/j.efsa.2021.6661	Modified molecular structure
Request for a scientific opinion on cetylated fatty acids as a novel food (NF 2020/1828)	21/07/2021	https://doi.org/10.2903/j.efsa.2021.6670	Modified molecular structure
Request for a scientific opinion on whole and ground crickets (Acheta domesticus) as a novel food (NF 2018/0804)[a]	17/08/2021	https://doi.org/10.2903/j.efsa.2021.6779	Derived from animals or their parts

Request for a scientific opinion on whole and ground mealworm (Tenebrio molitor) larvae as a novel food (NF 2018/0802)[a]	25/08/2021	https://doi.org/10.2903/j.efsa.2021.6778	Derived from animals or their parts
Request for a scientific opinion on pasteurised Akkermansia muciniphila as a novel food (NF 2019/1366)	01/09/2021	https://doi.org/10.2903/j.efsa.2021.6780	Derived from microorganisms, fungi or algae
Request for a scientific opinion on mung bean protein as a novel food (NF 2020/1651)[a]	20/10/2021	https://doi.org/10.2903/j.efsa.2021.6846	Derived from plants or their parts
Request for a scientific opinion on Galacto-oligosaccharide (NF 2019/1154)	27/10/2021	https://doi.org/10.2903/j.efsa.2021.6844	Derived from microorganisms, fungi or algae
Request for a scientific opinion on nicotinamide riboside chloride as a novel food (NF 2020/1613)	12/11/2021	https://doi.org/10.2903/j.efsa.2021.6843	Vitamins, minerals and other substances
Request for a scientific opinion on water lentil powder from Lemnaceae as a novel food (NF 2018/0430)	15/11/2021	https://doi.org/10.2903/j.efsa.2021.6845	Derived from plants or their parts
Request for a scientific opinion on IHAT (Iron Hydroxide Adipate Tartrate) as a novel food (NF 2019/1417)	10/12/2021	https://doi.org/10.2903/j.efsa.2021.6935	- Vitamins, minerals and other substances - Engineered nanomaterials
Request for a scientific opinion on Wolffia globosa powder as a novel food (NF 2019/1223)	22/12/2021	https://doi.org/10.2903/j.efsa.2021.6938	Derived from plants or their parts
Request for a scientific opinion on Eurycoma longofolia (tongkat ali) root extract as a novel food (NF 2018/0169)	22/12/2021	https://doi.org/10.2903/j.efsa.2021.6937	Derived from plants or their parts
Request for a scientific opinion on tetrahydrocurcuminoids from turmeric (Curcuma longa) as a novel food (NF 2020/1526)	22/12/2021	https://doi.org/10.2903/j.efsa.2021.6936	Derived from plants or their parts
Request for a scientific opinion on edible Jatropha curcas L. kernels (Chuta) as a novel food (NF 2018/0177)	21/01/2022	https://doi.org/10.2903/j.efsa.2022.6998	Derived from plants or their parts
Request for a scientific opinion on Schizochytrium sp. oil as a novel food (NF 2019/1213)	31/01/2022	https://doi.org/10.2903/j.efsa.2022.7083	Derived from microorganisms, fungi or algae
Request for a scientific opinion on dried coffee husk (Cascara) from Coffea arabica L. as a novel food (NF 2018/0192)	25/02/2022	https://doi.org/10.2903/j.efsa.2022.7085	Derived from plants or their parts
Request for a scientific opinion on 2'-Fucosyllactose/ difucosyllactose mixture as a novel food (NF 2019/1457)	03/03/2022	https://doi.org/10.2903/j.efsa.2022.7140	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on Lacto-N-tetraose (LNT) as a novel food (NF 2019/1456)	03/03/2022	https://doi.org/10.2903/j.efsa.2022.7140	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on Galacto-oligosaccharide (GOS) as a novel food (NF 2020/1606)	30/03/2022	https://doi.org/10.2903/j.efsa.2022.7203	Derived from microorganisms, fungi or algae

Request for a scientific opinion on pea and rice protein fermented by Shiitake mushroom (Lentinula edodes) mycelia as a novel food (NF 2019/1459)[a]	06/04/2022	https://doi.org/10.2903/j.efsa.2022.7205	Derived from microorganisms, fungi or algae
Request for a scientific opinion on Beta-lactoglobulin as a novel food (NF 2020/1707)	08/04/2022	https://doi.org/10.2903/j.efsa.2022.7204	Derived from animals or their parts
Request for a scientific opinion on 2'-Fucosyllactose as a novel food (NF 2019/1350)	04/05/2022	https://doi.org/10.2903/j.efsa.2022.7257	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on Lacto-N-neotetraose as a novel food (NF 2019/1359)[a]	04/05/2022	https://doi.org/10.2903/j.efsa.2022.7257	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on bovine milk osteopontin as a novel food (NF 2020/1698)	06/05/2022	https://doi.org/10.2903/j.efsa.2022.7137	Derived from animals or their parts
Request for a scientific opinion on defatted whole cricket (Acheta domesticus) powder as a novel food (NF 2019/1227)[a]	13/05/2022	https://doi.org/10.2903/j.efsa.2022.7258	Derived from animals or their parts
Request for a scientific opinion on Lacto-N-tetraose (LNT) as a novel food (NF 2020/1809)[a]	16/05/2022	https://doi.org/10.2903/j.efsa.2022.7242	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on 3'-Sialyllactose (3'-SL) (NF 2020/1794)	25/05/2022	https://doi.org/10.2903/j.efsa.2022.7331	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on 3-Fucosyllactose (3-FL) as a novel food (NF 2020/1620)	25/05/2022	https://doi.org/10.2903/j.efsa.2022.7329	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on Vitamin D_2 mushroom powder as a novel food (NF 2019/1471)	10/06/2022	https://doi.org/10.2903/j.efsa.2022.7326	Derived from microorganisms, fungi or algae
Request for a scientific opinion on Zinc L-carnosine as a novel food (NF 2019/1090)	10/06/2022	https://doi.org/10.2903/j.efsa.2022.7332	- Modified molecular structure - Vitamins, minerals and other substances
Request for a scientific opinion on Antrodia camphorata mycelia powder as a novel food (NF 2018/0329)	29/06/2022	https://doi.org/10.2903/j.efsa.2022.7380	Derived from microorganisms, fungi or algae
Request for a scientific opinion on frozen and freeze-dried formulations of the lesser mealworm (Alphitobius diaperinus larva) as a novel food (NF 2018/0125)[a]	04/07/2022	https://doi.org/10.2903/j.efsa.2022.7325	Derived from animals or their parts
Request for a scientific opinion on Yarrowia lipolytica yeast biomass as a novel food (NF 2020/1950)[a]	28/07/2022	https://doi.org/10.2903/j.efsa.2022.7450	Derived from microorganisms, fungi or algae
Request for a scientific opinion on iron milk proteinate (IMP) as a novel food (NF 2020/1866)	16/09/2022	https://doi.org/10.2903/j.efsa.2022.7549	Vitamins, minerals and other substances

Request for a scientific opinion on β-Hydroxybutyrate salts (Sodium/ Magnesium/Calcium) as a novel food (NF 2018/0291)	13/10/2022	https://doi.org/10.2903/j.efsa.2022.7449	Modified molecular structure
Request for a scientific opinion on an aqueous ethanolic extract of Labisia pumila as a novel food (NF 2019/1337)	10/11/2022	https://doi.org/10.2903/j.efsa.2022.7611	Derived from plants or their parts
Request for a scientific opinion on Lemna minor (and Lemna gibba) whole plant material as a novel food (NF 2020/1757)	30/11/2022	https://doi.org/10.2903/j.efsa.2022.7598	Derived from plants or their parts
Request for a scientific opinion on 6'-Sialyllactose (6'-SL) as a novel food (NF 2020/1801)	07/12/2022	https://doi.org/10.2903/j.efsa.2022.7645	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on 2'-Fucosyllactose (2'-FL) as a novel food (NF 2020/1825)	14/12/2022	https://doi.org/10.2903/j.efsa.2022.7647	- Modified molecular structure - Derived from microorganisms, fungi or algae
Request for a scientific opinion on whole seeds of oilseed rape as a novel food (NF 2018/0590)[a]	12/01/2023	https://doi.org/10.2903/j.efsa.2023.7706	Derived from plants or their parts
Request for a scientific opinion on cellobiose as a novel food (NF 2020/1805)	13/01/2023	https://doi.org/10.2903/j.efsa.2022.7596	Modified molecular structure
Application for modification of use of Xia Powder 435 as a novel food	13/04/2023	https://doi.org/10.2903/j.efsa.2023.7904	Derived from plants or their parts
Request for a scientific opinion on water lentil protein concentrate from a mixture of Lemna gibba and Lemna minor as a novel food (NF 2018/0801)	27/04/2023	https://doi.org/10.2903/j.efsa.2023.7903	Derived from plants or their parts

[a] NF mandates meeting three criteria according to the EFSA checklist and selected for their "relatively" high social media prominence.

Annex C

Results of the scientific literature search.

NF assessed	Study (authors, year)	Method	Main findings
Insect-based food	Verbeke, 2015	Experimental study in BE	Readiness to adopt insects stronger among younger consumers compared to older consumer; willingness to eat is low overall.
	Gmuer et al., 2016	Experimental study in CH	The higher the degree of processing of the insect ingredient (flour or bits instead of whole crickets), the more positive consumers are.
	Hartmann and Siegrist, 2016	Experimental study in CH	People who consumed a processed insect product report a higher willingness to eat unprocessed insects.
	Megido et al., 2016	Experimental study in BE	Influence of experience: people who have already heard about entomophagy or eaten insects in the past rate insect burgers' taste higher.
	Tan, van der Berg, and Stieger, 2016	Experimental study in NL	Food neophobia is the main factor determining consumers' readiness or not to adopt insects as a meat replacement.
	Ardoin and Prinyawiwatkul, 2021	Literature review	Disgust is the most salient and immediate reaction to eating insects in the West and plays a major role in entomophagy avoidance.
	Wendin and Nyberg, 2021	Literature review	Major barrier to edible insect consumption: lack of information available on alternative protein, cooking methods and preparation of dishes using insects.
	Marquis et al., 2023	Experimental study in FR and CO	The use of cute visual elements on insect-based product packaging can positively affect young adult consumers' perception and acceptance.

Cell culture-derived meat	Verbeke et al., 2015	Experimental study in BE, PT, UK	Potential personal and societal risks outweigh the expected benefits, as benefits are believed to be situated at the global societal rather than at the personal or individual level.
	Verbeke, Sans and Van Loo, 2015	Experimental study in BE	Possible repulsion or the so-called "yuck factor" is the typical initial reaction that consumers feel at the idea of eating cell culture-derived meat.
	Bryant and Barnett, 2018	Literature review	Preference for cell culture-derived meat is higher amongst men, younger people, more educated people, those who consume meat substitutes, and those with high concern for the environment.
	Bryant and Barnett, 2019	Experimental study in US	Test of different names. "Lab grown meat": most negative associations (artificiality/unnaturalness and disgust). "Cultured meat": associations with science, deviations from nature. "Clean meat": associations with healthiness / nutrition, tastiness, cleanness, and naturalness.
	Bryant and Dillard, 2019	Experimental study in US	More technical descriptions of cell culture-derived meat led to lower acceptance compared to less technical descriptions, as they are associated with science and unnaturalness.
	Siegrist and Hartmann, 2020a	Literature review	Consumers' reactions: perception of unnaturalness and feeling of disgust, therefore low acceptance. Consumers consider factors like taste and price rather than animal welfare.
	Siegrist and Hartmann, 2020b	Experimental study in AU, CH, UK, FR, DE, MX, SA, ES, SE, US	Cultural differences identified: low levels of acceptance in France, high in Mexico, South Africa and England.
	Tomiyama et al., 2020	Literature review	Consumers' concerns revolve around the adverse societal consequences associated with the loss of culinary traditions, rural livelihoods, and the preservation of livestock, open space and biodiversity.
	Wilks, Homsey and Bloom, 2021	Experimental study in US	The thought of eating cell culture-derived meat, rather than the process of creating it, triggers the feeling that it is "unnatural".
Insect-based and cell culture-derived meat	Hartmann and Siegrist, 2017	Literature review	Consumer's willingness to reduce their meat consumption is generally low. Health reasons are perceived as more convincing compared with environmental reasons to reduce meat consumption.
Plant- and insect-based proteins	De Koning et al., 2020	Experimental study in BR, CN, DR, ES, FR, NL, NZ, UK, US	Food neophobia and food technology neophobia influence the behavioural intentions and decrease the willingness to try, buy, and pay more for meat-alternative proteins.
Plant- and insect-based meat, algae, and cell culture-derived meat	Tso, Lim and Forde, 2020	Literature review	Consumers are motivated mostly by health concerns when opting for alternative proteins, and less by sustainability, environmental or animal welfare concerns.
Plant- and animal-based food	Faber et al., 2021	Experimental study in DE, DK, ES	Consumers not in favour of products deviating substantially from what is perceived as "natural"; more interest in plant-based proteins.
Pulses, algae, insects, plant-based meat alternatives, and cell culture-derived meat	Onwezen et al., 2021	Literature review	Plant-based meat alternatives and pulses are most accepted, insects are least accepted, and cell culture-derived meat is in-between.
Plant- and insect-based food, and cell culture-derived meat	Possidónio et al., 2021	Experimental study in PT	Effect of framing: presenting meat alternatives in a meal has a more positive impact than presenting them as individual products.

Plant- and insect-based food	Anusha Siddiqui et al., 2022	Literature review	Acceptance of novel food technologies influenced by: 1) food technology aspects: voluntary exposure, perceived naturalness, perceived dread and perceived control; and 2) people's characteristics: disgust sensitivity, food technology neophobia, cultural values.
Plant-, insect-based meat, and cell culture-derived meat	Siegrist and Hartmann, 2023	Literature review	Acceptance of insect-based and cell culture-derived meat is low, while for plant-based meat it is high.
Precision fermentation	Broad et al., 2022	Experimental study in DE, UK, US, and SG	Concerns about the interference of human technology with nature and the potential health risks; animal welfare seen as the only benefit.
	Banovic and Grunert, 2023	Experimental study in DE, DK and PL	Framing this technology as natural and similar to traditional fermentation increased acceptance, trust levels and perceived benefits.
Microalgae	Van der Stricht et al., 2023	Experimental study in DE, ES, HU, IT and NL	Willingness to pay affected by the product label: highest for organic label, followed by "healthy and nutritious" label, and least for a vegan label.

AU: Australia; BE: Belgium; BR: Brazil; CH: Switzerland; CN: China; CO: Colombia; DE: Germany; DK: Denmark; DR: Dominican Republic; ES: Spain; FR: France; HU: Hungary; IT: Italy; MX: Mexico; NL: The Netherlands; NZ: New Zealand; SG: Singapore; PL: Poland; PT: Portugal; SA: South Africa; SE; Sweden; UK; United Kingdom; US: United States