frontiers in Sustainable Food Systems

SYSTEMATIC REVIEW
published: 01 February 2022
doi: 10.3389/fsufs.2021.799587

Driving Management of Novel Foods: A Network Analysis Approach

Carla Zarbà, Gaetano Chinnici, Manal Hamam, Salvatore Bracco, Biagio Pecorino and Mario D'Amico*

Department of Agriculture, Food and Environment (Di3A), University of Catania, Catania, Italy

The food industry has confronted, in recent years, numerous issues including meeting a food demand for individual well-being in a sufficient and healthy manner, also due to the effects of the world population growth. In this scenario, alternative food sources may be a key element both for their contribution to food needs and for the promotion of sustainable and innovative production patterns. These food sources, new compared to traditional food styles, have been regulated by specific European Union regulations under the definition of novel foods. Their importance in the world has raised different topics of scientific research. The present paper aimed to seize the direction of scientific studies in the world focused on the thematic area of novel foods, from a management point of view. This study analyzed 209 papers and carried out a descriptive analysis and a network analysis of the thematic areas under examination also with the help of the software VOSviewer. The results highlighted the importance of scientific research in the world also for the contributions on the exploration of existing markets as well as for the innovative solutions it provides, which aim to expand market possibilities. Finally, the existence of several elements and factors, which may discourage the propensity to consume and therefore the development of the novel foods market, seemed to emerge, and for this reason, many surveys focused on finding solutions to overcome these potential obstacles.

Keywords: novel foods, management, network analysis, VOSviewer, occurrences

OPEN ACCESS

Edited by:
Karl Matthews,
Rutgers, The State University of New Jersey, United States

Reviewed by:
Ryo Kohsaka,
Nagoya University, Japan
Aida Turrini,
Independent Researcher, Rome, Italy

****Correspondence:***
Gaetano Chinnici
chinnici@unict.it

Specialty section:
This article was submitted to Agro-Food Safety, a section of the journal Frontiers in Sustainable Food Systems

Received: *21 October 2021*
Accepted: *13 December 2021*
Published: *01 February 2022*

Citation:
Zarbà C, Chinnici G, Hamam M, Bracco S, Pecorino B and D'Amico M (2022) Driving Management of Novel Foods: A Network Analysis Approach. Front. Sustain. Food Syst. 5:799587. doi: 10.3389/fsufs.2021.799587

INTRODUCTION

In recent years, the issue of obtaining necessary food for individual well-being in a sufficient and healthy manner has received increasing attention from institutions at all levels internationally.

The various reasons for this considerable interest can be summarized in the urgency of the shortage of food resources in the face of continuous population growth (Marberg et al., 2017).

According to FAO (2019) data, between 2007 and 2017, the population of the European continent tended to grow by slightly +3% (746.4 million), and the rural population, on the other hand, progressively declined by −11% (189.7 million). On the other hand, in parallel, the world population increased by almost +30% (7.6 billion) mainly as a result of the sharp increases recorded in Africa, the Americas, and Asia. Those growth impulses, among others, led the FAO to forecast a world population of ∼9.7 billion people by 2050 (FAO, 2019), with pressure on the environment of extraordinary magnitude and a growing demand for food security.

In such a scenario, the nutrition sphere represents an element of prime importance, since the difficulty to eat in an adequate and healthy manner is a global challenge that makes its weight felt

also in the wealthiest countries where food security and environmental sustainability are among the drivers of food demand (Belluco et al., 2013).

The need for alternative food sources to those conventionally consumed especially in Western countries often produced according to sustainable models determined the choice of the focal point of this study on novel foods. Another reason behind this choice is that novel foods may represent a possible solution to respond to the problems that characterize the current worldwide emergency context. Algae and insects are examples paving the way toward new future perspectives (van Huis et al., 2013).

Insects (EFSA, 2021; FAO, 2021) and algae (Diener et al., 2006; Gouveia et al., 2008; Multineddu, 2012; Uslu et al., 2013; Bruhn et al., 2019; Pereira et al., 2019) contain high nutritional characteristics such as high fat, protein, vitamin, fiber, and mineral and represent a healthy food source for human consumption. They can be eaten *as a whole* or *processed into either granular or paste forms* (van Huis et al., 2013). So, not only insects and algae constitute a potential substitute to conventional proteins, but their production meets environmentally friendly standards, the first being *harvested in the wild* (van Huis et al., 2013) and the second produced with low soil requirement, low emissions, etc. (Zarbà et al., 2020a,b; Aquaculture Advisory Council, 2021).

The growing attention toward this kind of food and similar categories new for the European Union market raise the need to regulate the international trade for these specific products.

In this context, the European Union proposed, with its "novel foods," production and consumption models to counteract the emergence of these issues (Zarbà et al., 2021), so a careful assessment of the latter may contribute to define sustainable development paths, in terms of safeguarding natural resources and biodiversity (Halpern et al., 2021) and food quality, through consumption styles.

These implications already assumed global relevance in the 1990s and focused the EU's attention on novel foods or novel food ingredients, requiring an assessment of their safety before their release on the member countries' market. This interest had to be balanced with the need to ensure the free movement of food, also to contain possible phenomena of unfair competition on the functioning of the internal market, since the Member States of the community had different provisions in this area.

With the evolving prosperous needs that the market manifested over time, the need to innovate the existing legislation arose (Loeber, 2011; Hyde et al., 2017). This is the case of the amendments dedicated to novel foods' law that allowed to consider, among novel foods, foods produced by new techniques not foreseen and foreseeable by the legislator of 1997 (Formici, 2020). Indeed, as of January 1, 2018, Regulation (EU) 2015/2283 of the European Parliament and of the Council repealed and replaced Regulation (EC) No. 258/97.

The new regulatory approach has established favorable conditions for the agri-food sector that may benefit from the introduction of new and innovative food products (novel foods) on the market of EU countries, while maintaining a high level of food safety for the consumer (Lähteenmäki-Uutela et al., 2021), centralizing and establishing definite times for the authorization procedures.

Besides, the new regulation has introduced, for the so-called traditional foods coming from third countries, procedures that are more streamlined. This aimed to overcome the political and institutional issues that the application of the previous regulation of 1997 had caused (Scaffardi, 2020).

Moreover, the new regulation in establishing procedures in the field of food safety had to adapt also to the procedures of the European Food Safety Authority [Regulation (EC) n. 178/2002 of the European Parliament and of the Council].

Of importance is the adaptation of Regulation (EU) 2015/2283 to the scientific and technological developments that have taken place, which have affected the need to clarify and update the scope of novel foods. In particular, after the first definition provided by Regulation (EC) n. 258/97, nowadays novel food means any food that was not used for human consumption to a significant degree within the Union before May 15, 1997, irrespective of the dates of accession of Member States to the Union, and that falls under at least one of the following categories indicated in Article 3(2)(a) of Reg. (EU) 2015/2283.

Later, pursuant to this new regulation, the European Commission established the novel foods Union's list implementing Regulation (EU) 2017/2470 of December 20, 2017. The Union's list is constantly updated following new novel food authorizations granted on the basis of the market evolutionary dynamics developed continuously worldwide and supported by scientific and technological evidence.

The dynamics of the scientific and technological evolutions taking place on a global scale contribute to determine the continuous updating of the list of novel foods authorized for placing on the market in the EU.

In the current process of development of advanced skills, as well as the previously underlined emerging problems affecting the globe, the present paper aims to seize the direction of scientific studies in the world focusing on the thematic area of novel foods, from the point of view of technical management and economic management.

In particular, the unfolding of the research had as reference the main worldwide databases, namely, the core collection of Elsevier Scopus and Web of Science (WOS), from which the elements were drawn to develop a descriptive analysis as well as a network analysis, using the software VOSviewer (Adegoriola et al., 2021). The aim was to identify the trend of the research area, the top journals, the leading countries in this area of research, and the main topic of this field of research.

Another aim was to understand whether the direction taken by scientific studies in the world would have also revealed elements that would have led to the conclusion of the existence of influences on firms and on the market.

METHODS

Database Selection: PRISMA

Through the adoption of the qualitative Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)

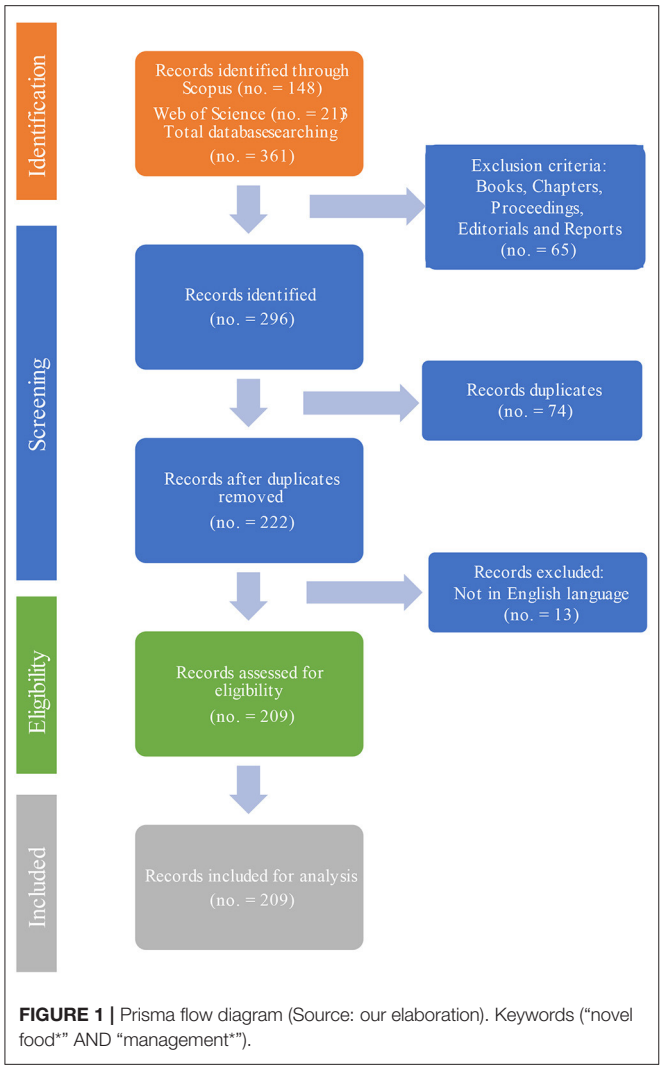

FIGURE 1 | Prisma flow diagram (Source: our elaboration). Keywords ("novel food*" AND "management*").

(Moher et al., 2015; Maesano et al., 2021; Page et al., 2021; Spina et al., 2021), the research conducted in these articles had as reference the online core collection of Elsevier Scopus and Web of Science (WOS). These world scientific/economic online research databases allowed acquiring the direction of the specific literature scientific studies in the world, in a given historical moment.

First of all, the thematic area of research was determined by focusing on novel foods combined with management (Identification), in order to include both technical and economic-management aspects. For this purpose, to develop the research, "Novel Food*" and "Management*" were used as keywords. The last and final collection took place on July 19.

The PRISMA procedure adopted followed a detailed protocol (Dardonville et al., 2021) to be replicable, scientific, and transparent (Spina et al., 2021), for article collection from the bibliographic sources utilized (**Figure 1**).

A data cleaning approach led us to exclude duplicates and to include only articles and reviews (Screening), and, among them, only those in English language in order to consider literature with high visibility within the scientific community (Maesano et al., 2021).

The next phase that commonly characterizes the PRISMA method is the Eligibility Phase (González-Sarrías et al., 2017; Golbabaei et al., 2020; González-Rubio et al., 2020). However, since the methodological structure followed for the present work included and continued with data processing with VOSviewer (Esfahani et al., 2021; Norouzi et al., 2021), at this stage, no article was excluded to avoid the implication of narrowing the scope of the research (Eligibility).

The protocol process concluded by including all 209 articles (**Supplementary Material**), which represented the universal data of the present analysis (Included).

VOSviewer Co-occurrence Analysis Procedure

The investigation continued utilizing the VOSviewer tool. This is a free JAVA-based software, developed in 2009 by Van Eck and Waltman (2010) of the Centre for Science and Technology Studies (CSTS) at Leiden University in the Netherlands, for creating maps based on network data (Van Eck and Waltman, 2018). This software develops network analysis by processing bibliometric maps (Damar et al., 2018) that provide visualization of various network forms of scientific publication data by combining many factors through a quantitative method.

The combination of the two methodological approaches led to import the data, keywords, titles of articles, and abstracts (TITLE_ABS_KEY), which were gathered through the PRISMA method, into the VOSviewer software (**Figure 2**). In particular, VOSviewer allowed processing the so-called co-occurrence network map of keywords of all selected articles from the databases under consideration, spanning all available search periods (1987–2021).

OVERVIEW OF GLOBAL SCIENTIFIC PUBLICATIONS

Descriptive Analysis

The PRISMA methodology had also made it possible to carry out descriptive analyses. In particular, the extracted data from Scopus and WOS allowed describing the geographical distribution, the total annual distribution of the total number of papers per year, and the major journals in the area of interest.

Distribution Per Year

Figure 3 shows the evolution of scientific production in the entire period of activity, i.e., 1987–2021, on the topic selected, "Novel Food*" and "Management*."

In the early stage of activity, the number of articles was quite limited; in fact, from 1987 until 2001, only one article was registered each year, with the exception of the years 1997 and 2003, where two articles were published, and 2002, which registered five publications. In the years 2006 and 2007, the number was 6 and 7, respectively, followed by a decrease in 2008 and 2009, both showing just three articles. In the year 2010, the number of articles reached 12, decreasing gradually in 2011 and

FIGURE 2 | VOSViewer procedure (Source: our elaboration).

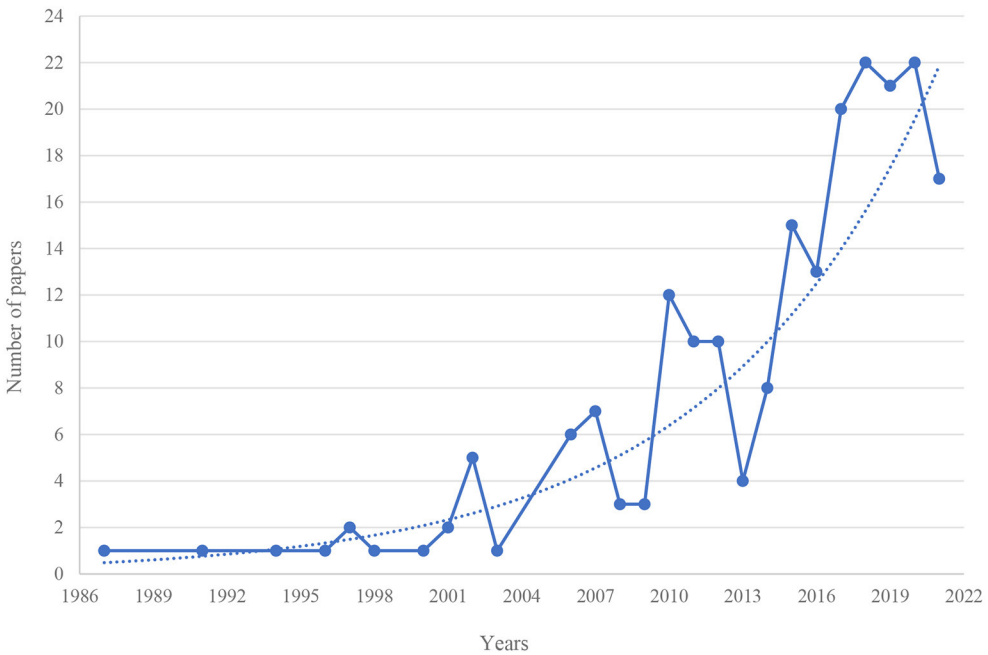

FIGURE 3 | Number of papers per year (Source: our elaboration).

2012 with 10 articles and then dropped to 4 articles in 2013. Afterwards, there was a growing trend until the year 2020, with a starting slight increase in 2014 with 8 articles and 15 in 2015 (temporarily interrupted in 2016 with 13 articles), 20 in 2017, 22 in 2018, a faint decrease of one publication in 2019, and 22 in 2020.

Regarding 2021, it must be considered that it is ongoing, so the related data, showing 17 articles, are not definitive. Therefore, the growing trend of recent years and the considerable number of articles already published in the first semester of the current year suggest that the year 2021 will show a final development trend.

The increasing trend that identified the latest years as the most productive period revealed the flourishing attention around the "Novel Food*" and "Management*" topics.

Geographical Area Affiliation

Figure 4 shows, in a worldwide map, the distribution of author affiliations of the 209 scientific studies selected from different countries. Colors indicate the number of studies developed in each country. In the gray area, none of the studies were present; light colors identify a small number of studies, while the darker the color, the greater the number of papers present in the relevant area. The map showed that author affiliation was not uniformly distributed geographically. The total number of author affiliations was 438. Most of them belonged to developed countries, mainly in Europe with 262 and in the Americas with 81.

In particular, the European country with the highest number of affiliations was the UK with 38, followed by Italy with 27 and Holland with 26, while in North America, the US had 47 papers.

In Asia, China stood out with a number of affiliations equal to 14; in Australia, there were 12 units, while in Africa, the number of affiliations was 12 and the most representative country, with 4 units, was South Africa.

In light of these data, it is possible to assert that the novel foods topic was the object of scientific interest of many universities in the world.

Top Journals

The top journals with the highest number of articles published in the selected period (1987–2021) are shown in **Figure 5**.

The *Journal of Cleaner Production* and *Trends in Food Science Technology* stood out for the major number of articles

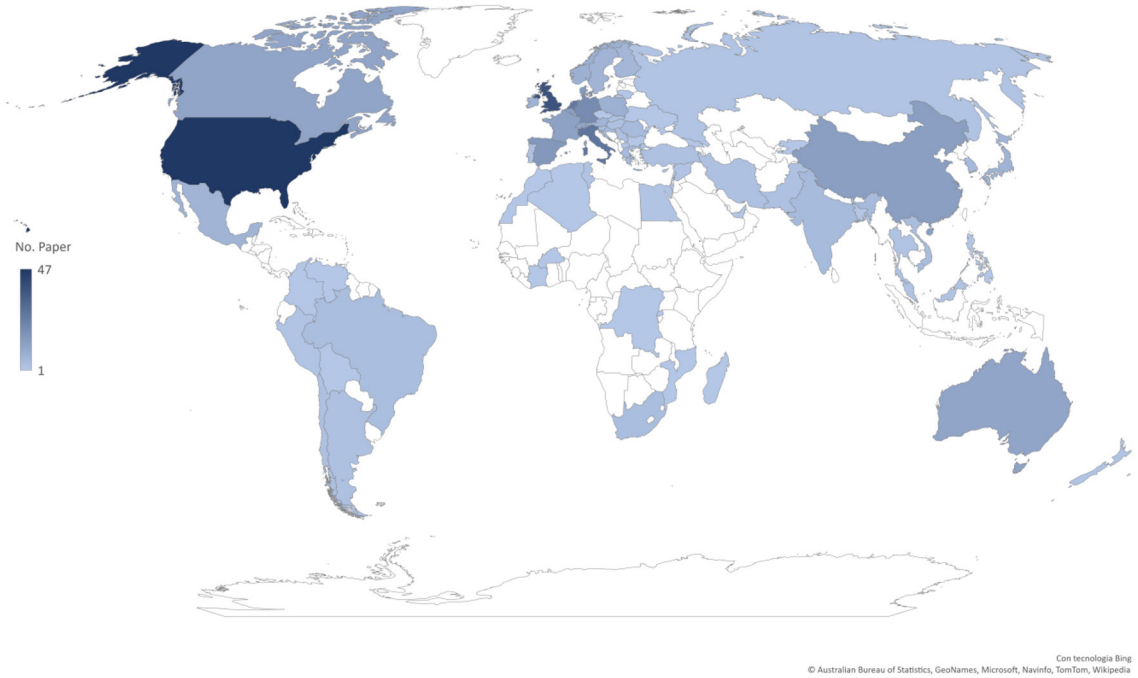

FIGURE 4 | Countries where the selected studies were conducted (Source: our elaboration).

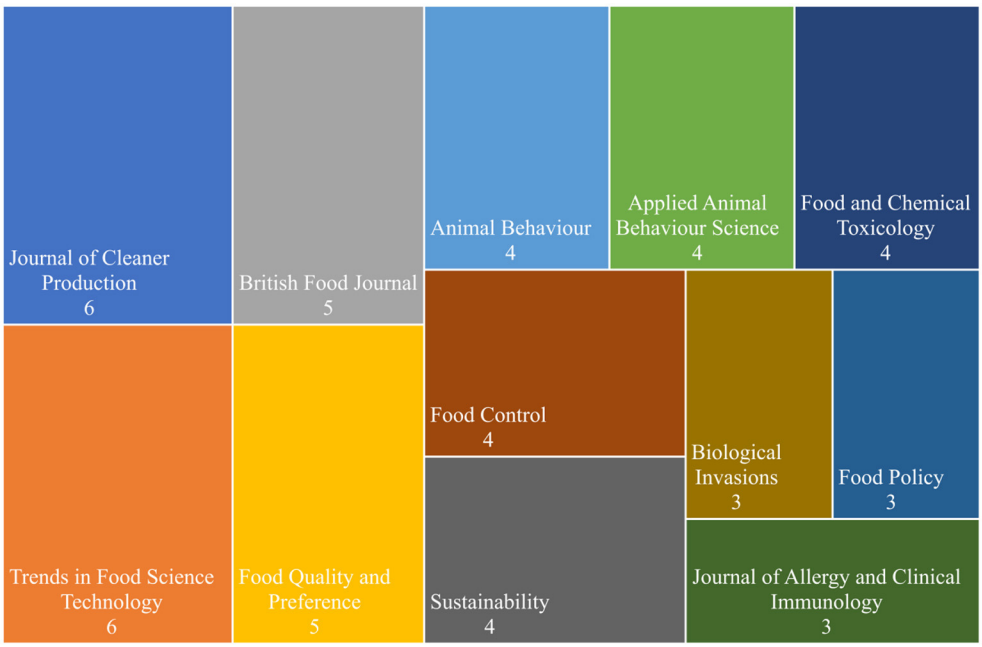

FIGURE 5 | Top Journals where the selected studies were conducted (Source: our elaboration).

published, with six publications each. *British Food Journal* and *Food Quality and Preference* registered five publications each. *Animal Behaviour*, *Applied Animal Behaviour Science*, *Food and Chemical Toxicology*, *Food Control*, and *Sustainability* published four papers each. *Biological Invasions*, *Food Policy*, and *Journal of Allergy and Clinical Immunology* issued three articles.

Ultimately, the journals that published papers on novel foods were related to different topics and this confirmed the results

drawn from the network analysis and then discussed, which showed that the novel foods (combined with management) thematic area is not only highly studied, but also analyzed under different perspectives and profiles.

VOSVIEWER RESULTS

VOSviewer Co-occurrence Analysis Results

The statistical keywords analysis with VOSviewer allowed us to discover the most used terms and their relationships, from which the main research topics related to the analyzed field can be derived. The results also allowed us to evaluate trending topics of current research also with a view to glimpse possible future trends (Martínez-Vázquez et al., 2021). In concrete terms, this happened through the co-occurrence analysis of keywords and the visualization of the relative network map.

In performing the co-occurrence map elaboration, a technical difficulty arose: the data garnered from Scopus and WOS did not have the same language; therefore, it was necessary to create a uniform language line to indicate all the information in a single file. Hence, it was necessary to intervene on the Ris file elaborated by those databases giving univocal indication to all the gathered elements: keywords, titles of articles, and abstracts.

The resulting file was imported into VOSviewer to develop a single network analysis of the aforementioned three research data (TITLE_ABS_KEY), according to their relevance and co-occurrence, following the ensuing flow (Arias et al., 2021):

- Map based on bibliographic data;
- Type of analysis: co-occurrence;
- Unit of analysis: keywords;
- Counting method: full counting;
- Minimum number of occurrences of a term: 3 (output 67 keywords);
- Number of terms selected: total number of items;

When using the keyword co-occurrence feature, VOSviewer software provides two options: full counting and fractional counting.

Fractional counting reduces the influence of documents with many authors. As for full counting, the occurrence attribute indicates the total number of occurrences of a term in all documents (Van Eck and Waltman, 2018).

The difference between the two counting methods lies in the strength of the links that each creates.

Trying both tools for the aggregation of keywords, and after having evaluated the results of the two relative different elaborations of the network, it proved appropriate to use full counting, in line with other authors (Arias et al., 2021; Pan et al., 2021; Raboaca et al., 2021), for three reasons.

First of all, VOSviewer gives the option of full counting by default, and this circumstance is the first reason for its use, but above all, what pushed toward the adoption of this alternative, compared to fractional counting, is the consideration that it is more useful and consistent with our research (as verified by various attempts at aggregation). This is because, at the beginning, before using VOSviewer, the work already had a selective criterion approach at the origin. In fact, in adopting the PRISMA methodology, it was decided to combine the word "novel food" with the word "management" to restrict the field of research to our specific area of interest, with satisfactory results (in fact, with the string "Novel food*" AND "Management*," the database provided 209 papers).

Otherwise, those who used fractional counting (Lai et al., 2016), in accordance with its functionality (Van Eck and Waltman, 2018), mostly encountered data skimming needs. Sometimes, it is because they use only one keyword (Martinho, 2021) for the collection of the articles, or, in other cases, their search output resulted in a much larger number of papers (Dardonville et al., 2021) than those in this paper.

In addition, the skimming offered by fractional counting is automatic, hence driven by the software algorithm that reduces the number of words by 60%. Therefore, adopting fractional counting would have implicated the exclusion of numerous keywords and related aggregations useful for the present research; for this third reason, this option was left out. Consequently, full counting was preferred and, with regard to word reduction, a filter more suitable for our research had been identified. Specifically, a minimum extent intervention had been carried out by excluding only 6 keywords (allergy, anaphylaxis, asthma, gut microbiota, health, and obesity), believing that they would have dispersed the focus from the combined themes "novel food*" and "management*," as they were focused purely on medical aspects, therefore far from our field of interest. In addition, in adapting the keywords, "life-cycle-assessment" was removed considering it as a case of duplication of "life cycle assessment."

Moreover, the co-occurrence had been decreased from level 5, by default, to level 3, always to meet the same criterion chosen to have as much information available as possible to the present investigation; otherwise, increasing the number of co-occurrences would have led the software to exclude some connections by not allowing us to study them all. In fact, the number of keywords resulting in level 5 was 27; with level 3 eventually adopted, the number of keywords was 67, i.e., more numerous.

Once the map is elaborated, each node in the map represents a keyword and its different size depends on its occurrence frequency. The links show the co-occurrence relationships. Different colors characterize the keywords and distinguish them in different clusters.

The network map aggregated a total number of 61 keywords as shown in **Figure 6**.

The map highlighted that the keywords had been aggregated into five clusters according to their co-occurrence relationship (Du et al., 2021) (**Figure 7**).

The keyword co-occurrence analysis of the separate clusters allowed detecting some important data (**Figure 8**).

Probing the total link strength attributes, which indicate the total strength of one item relative to that of another item, the following considerations had been made.

Cluster 1, in red, was the most significant with 16 items. Its development was around the following topics: consumer

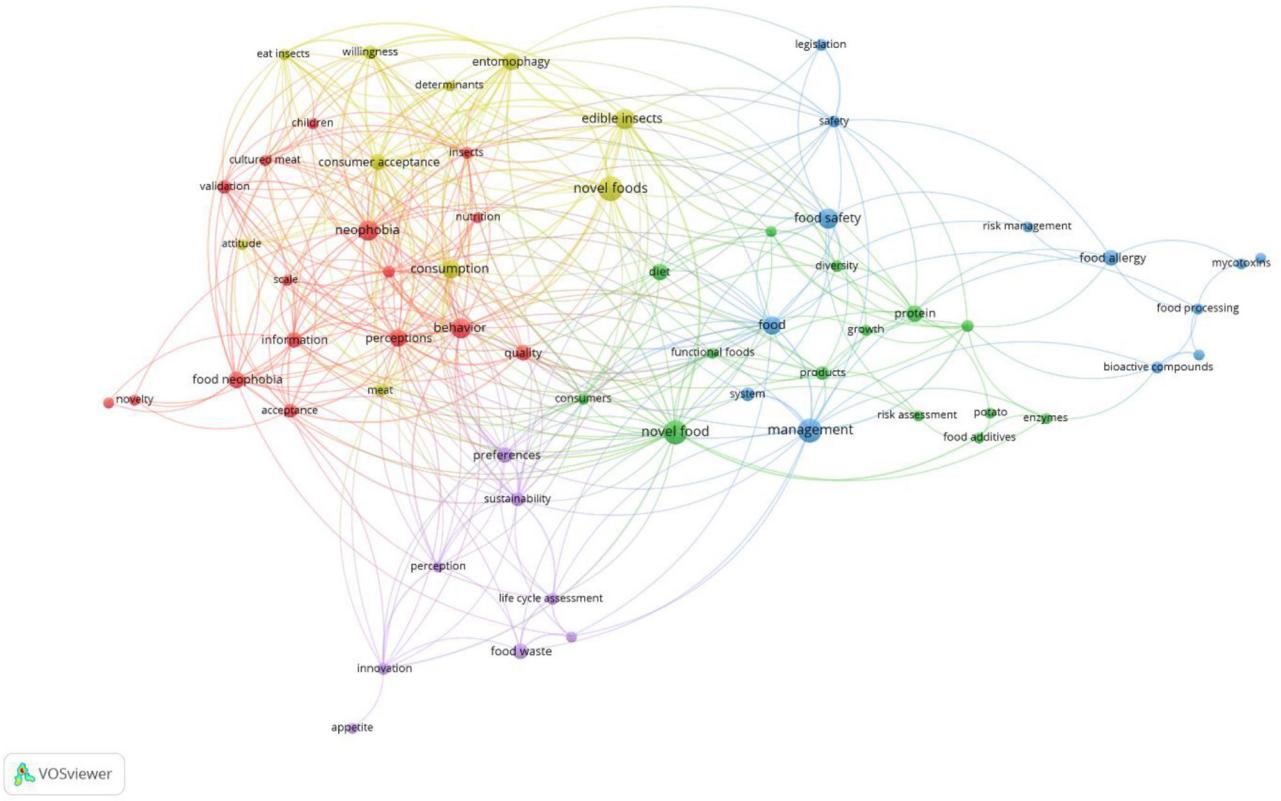

FIGURE 6 | Keyword co-occurrence map (Source: our elaboration).

FIGURE 7 | Cluster analysis (Source: our elaboration).

behavior, perception, level of acceptance, and neophobia. The keywords with the greatest weight were behavior, perceptions, and neophobia.

Cluster 2, in green, was mainly related to novel food characteristics seen as a product, i.e., their identification, their functionality, etc. The keywords with the greatest weight were novel foods and consumers.

Cluster 3, in blue, showed 13 key terms that focused on safety in various aspects: their management, their treatment as food, and risk management aspects. The keywords with the highest weight were food, management, and safety.

Cluster 4, in yellow, aggregated 10 keywords. It delved into consumption, consumer acceptance, and willingness to

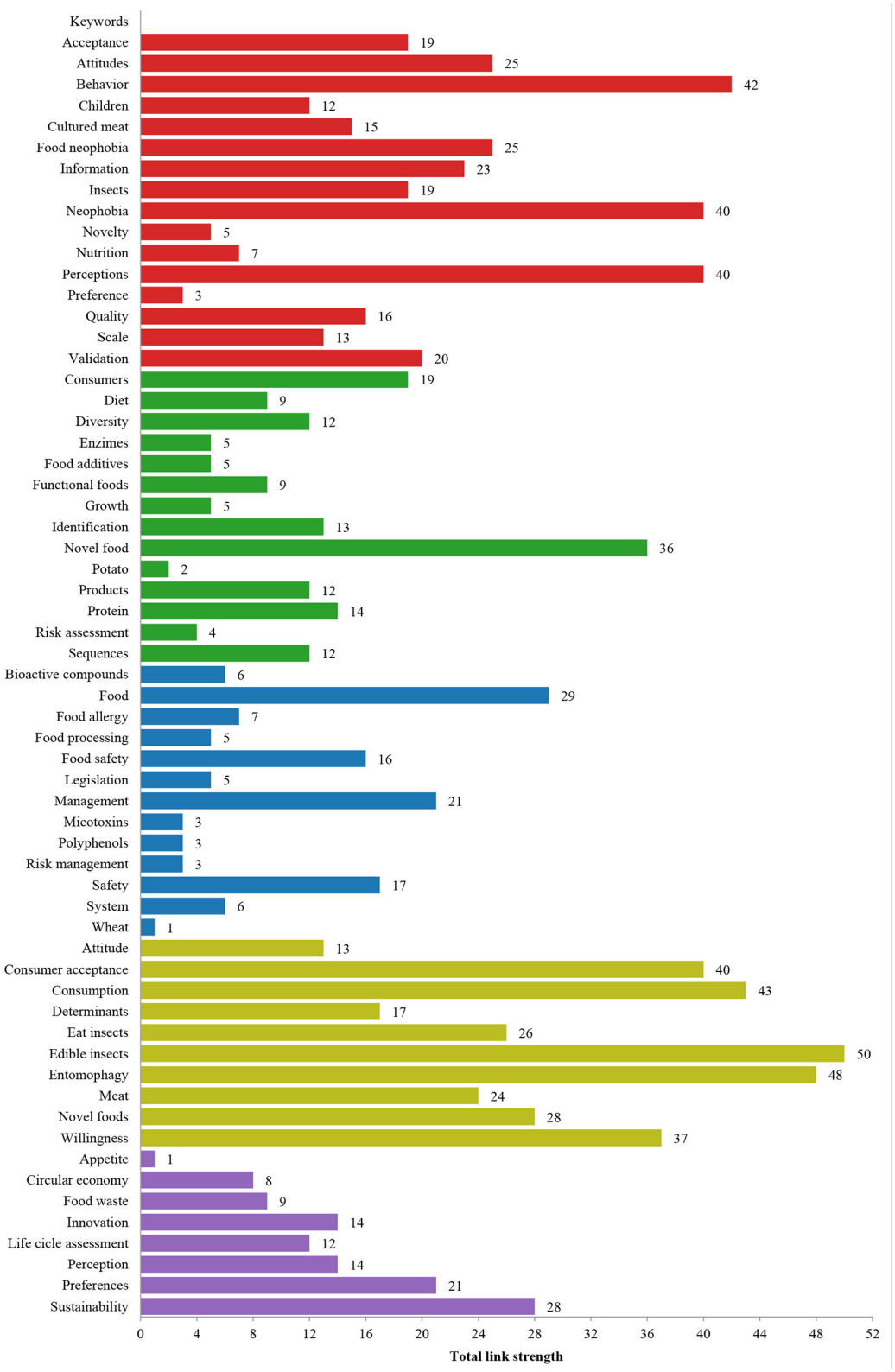

FIGURE 8 | Total link strength per cluster (Source: our elaboration).

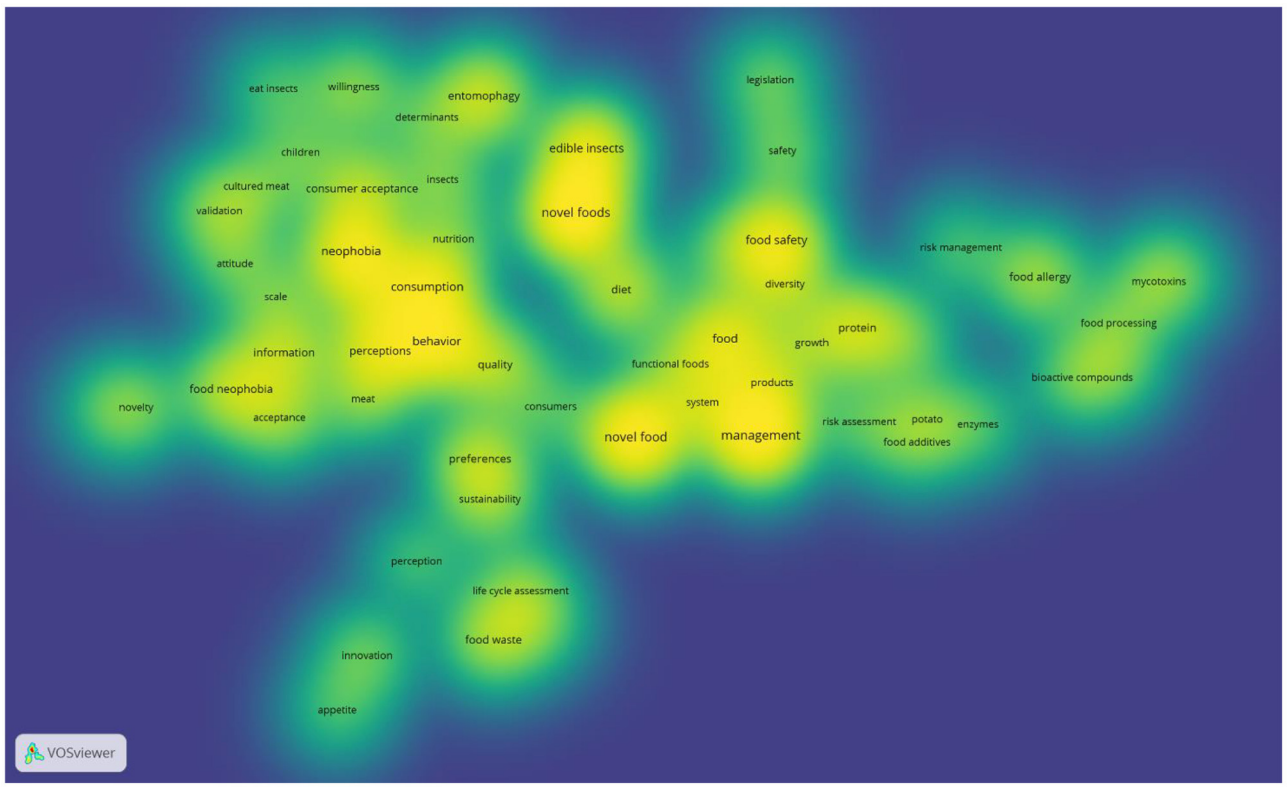

FIGURE 9 | Density map (Source: our elaboration).

try. The keywords with the most weight were edible insects, entomophagy, and consumption.

Cluster 5, in purple, had 8 nodes, and it was the smallest. It was mainly about sustainability, innovation, and circular economy. The keywords with the highest weight were sustainability, preferences, perceptions, and innovation.

VOSviewer Density Map Results

The density map by items allowed commenting the analysis at the node level. Each point in the item density visualization had a color that indicated the density of items at that point. By default, color range is from blue to green to yellow (Van Eck and Waltman, 2018). Yellow specifies the high weight of the neighboring items, blue indicates a small one, and green represents medium color density.

The density map shown in **Figure 9** detected the main topic discussed similarly to the network visualization and it did not add different elements.

VOSviewer High-Frequency Keywords Analysis

On the basis of the keyword co-occurrence analysis carried out, it was also possible to consider the keywords of all 5 clusters, resulting from the keyword network visualization, as a whole, and perform the high-frequency keywords (Liu et al., 2021) analysis of all their 61 items. At this scope, **Table 1** displays the keywords that appear at least ten times, the relative cluster and the relative color (in accordance with colors of **Table 1**), and their occurrence frequency.

TABLE 1 | High-frequency keywords of "Novel food*" and "Management*" *via* network visualization of VOSviewer.

Keywords	Cluster	Color (*)	Occurences
Behavior	1		10
Neophobia	1		10
Novel food	2		14
Food safety	3		10
Management	3		14
Edible insects	4		10
Novel foods	4		15

The colors in the table are in line with colors from Figure (Source: our elaboration).

The differences between the keyword co-occurrence analysis and the high-frequency keywords analysis lie in the fact that the former bases its results on the total link strength of the keywords, while the second dwells on the occurrence degree of the keywords (the occurrences attribute indicates the number of documents in which a keyword occurs; in the case of full counting, the occurrences attribute indicates the total number of occurrences of a term in all documents) (Van Eck and Waltman, 2018).

Moreover, while in the first case (**Figure 5**), the weight level of a keyword is related to those of the cluster it belongs to, in the second case (**Table 1**), the occurrence of the keyword is measured with respect to all 61 items. These different perspectives and findings gained prominence within the present research by enriching it.

Comparing the keywords of **Table 1** with those of **Figure 5**, some points of intersection and some differences emerged.

With respect to the intersection points, first of all, among the keywords that came up strongly in both analyses were as follows: novel foods in the double version, singular and plural, and management. This confirmed the centrality of these aspects, also reinforced, and gave value to the line of the present research, which is based on the choice of the combination of the keywords novel foods and management.

With regard to the differences, the high-frequency analysis highlighted, among the most important keywords, food safety, which, although present in cluster 3, resulting from the keyword co-occurrence analysis, did not show that there is enough weight to include it among the most relevant keywords. Other keywords (perceptions cluster 1, consumers cluster 2, food and safety cluster 3, and entomophagy and consumption cluster 4), which instead showed a strong weight within the 5 clusters, did not emerge in **Table 1** and even not one of the keywords grouped in cluster 5 emerged, since none of them had a minimum frequency of occurrence of 10 times. Such data could be presumable, in fact, as **Figure 5** shows that it is the smallest cluster, with a minor number of keywords.

VOSVIEWER DISCUSSIONS

From the analysis of the 209 papers collected, and in particular of those selected according to the keywords that had a higher total link strength in the five clusters identified in **Figure 5** and that had a high level of occurrence in **Table 1**, recurring topics emerged as follows: 1, consumer propensity; 2, consumer behavior; 3, neophobia; 4, strategies to increase the willingness to try of novel foods, linked to profiles relating to 4.1 human health and 4.2 environmental sustainability; 5, social ethical issues; 6, edible insect; 7, risk assessment; and 8, innovation.

1 and 2. The topics of consumer propensity and behavior toward the consumption of novel foods intersected. In this regard, it emerged that there were several studies on the factors that may influence the perception and behavior of the consumer (Dragone and Ziebarth, 2017; Specht et al., 2019; Coderoni and Perito, 2021; Traynor et al., 2021) and how consumers react to novel ingredients.

The fact that novel foods markets may depend on consumer willingness to try (Grahl et al., 2018) these types of food may explain numerous studies on what may increase novel food acceptance (Golbabaei et al., 2020; McCarthy et al., 2020; Barone et al., 2021). In fact, a lack of consumer propensity creates consequences on the market that could not develop largely in that sector (Jacobsen et al., 2014; Menozzi et al., 2017; Perrea et al., 2017; McCarthy et al., 2020; Zanetti et al., 2020).

3. This became even stronger in the case of food neophobia, defined by some authors as the unwillingness or refusal to eat, or the tendency to avoid, new foods (Martins et al., 1997; Tuorila and Hartmann, 2020; Zanetti et al., 2020), or general aversion to new food (Coderoni and Perito, 2021), or fear of trying new foods (Marberg et al., 2017). In fact, several researchers studied from what food is neophobia derived (Jang and Kim, 2015), who are affected by it (Okumus et al., 2021), etc. Other authors found that food neophobia and food technology neophobia negatively affect the likelihood of being willing to buy food produced with upcycled ingredients (Coderoni and Perito, 2021). Another part of literature stated that food neophobia negatively affects persuasion strategies but that the latter do have a positive influence on stated consumption intention [...] and that the negative effect of Food Neophobia Scale on the willingness to consume insects is fully mediated by persuasion strategies (Sidali et al., 2019).

4. Some studies on strategies (Direction Strategic, 2017) to increase willingness to try (Grahl et al., 2018; Sogari et al., 2019) and reduce neophobia (Park and Cho, 2016) of novel foods seemed to come from the same purpose of targeting consumers and stimulating the market for such products.

Moreover, these studies are based on two strands—the nutritional aspects related to health (Constable et al., 2007; Szakal et al., 2014; Agapito et al., 2018; Steffensen et al., 2018; Szparaga et al., 2019; Yue et al., 2020) and the aspect of environmental sustainability (Lähteenmäki-Uutela et al., 2017; de la Caba et al., 2019)—that were here below discussed separately.

4.1 Regarding the first strand, a part of the literature argued that novel foods may offer additional nutritional properties, compared to food products in general, with positive effects on human health (Ramprasath et al., 2015; Mancini and Antonioli, 2019) for consumers careful to these aspects. This consideration is assessed as an element of strategic marketing management for health-conscious consumers (Zanetti et al., 2020) and finally as a tool to reach consumers and direct them toward the consumption of novel foods. In addition, other studies reinforce this thesis by arguing that the spread of nutritional information about therapeutic features (Sidali et al., 2019) may reduce food neophobia related to new food and increase the willingness to try (Park and Cho, 2016; Zanetti et al., 2020).

Several authors showed, in fact, that insects present attractive nutritional profiles, representing a potential source of essential amino acids and proteins of animal origin and other vitamins and minerals (Belluco et al., 2013, 2017; Rumpold and Schlüter, 2013; Schlüter et al., 2017), so much so that consumers attentive to the decrease in meat consumption, believing that meat has a negative impact on human health (Mancini and Antonioli, 2019), seem to look for alternative protein sources (Belluco et al., 2013, 2017; Menozzi et al., 2017; Fernandez-Cassi et al., 2020). In this context, novel foods such as cultured meat (Mancini and Antonioli, 2019) and insects (Fernandez-Cassi et al., 2020) are important.

The meat consumption arguments, however, are related to the second strand, namely, environmental sustainability.

4.2 In particular, some research focused on the comparison between the environmental effects of cultured and conventional meat production processes, and it emerged that the former

entails more environmentally friendly techniques than the latter (Mancini and Antonioli, 2019). Although the energy use for cultured meat production seemed to be *comparable to that of beef* (Mattick et al., 2015), cultured meat seemed also to reduce land usage by 99%, water usage by 96%, and energy consumption by up to 45% (Tuomisto and Teixeira De Mattos, 2011; Mancini and Antonioli, 2019).

An aspect not to be underestimated is that, in economic terms, cultured meat production, according to some authors (Mancini and Antonioli, 2019), became very expensive. Other researchers stated, on the contrary, that *the production processes are not yet so advanced that cultured meat could currently be sold at a reasonable price in supermarkets or restaurants* (Dupont and Fiebelkorn, 2020). In a study by Post (2014) and Bohm et al. (2017), a case of economically affordable and sustainable production was described, i.e., a *cultured meat burger to be around 11 US dollars in 2016*.

In fact, some firms *in USA, Israel, Japan, and the Netherlands* are specialized *in the commercial* manufacture of cultured meat (German Bundestag, 2019; Dupont and Fiebelkorn, 2020).

Other studies focused on providing environmental criteria when selecting preservation methods for foods, as a way to develop more efficient and sustainable (Zarbà et al., 2020b) food products throughout their whole life cycle (Pardo and Zufía, 2012). This would prove the point that NFs are the key to addressing environmental issues to achieve sustainability (Belluco et al., 2015) of food production (Belluco et al., 2013) through more resource-efficient production approaches in the agriculture and food sector (Aschemann-Witzel and Peschel, 2019; Zarbà et al., 2020a). In fact, some authors stated results that are important to understand how consumers react to new ingredients and more resource-efficient production approaches (Aschemann-Witzel and Peschel, 2019).

5. Moreover, with regard to the production of cultured meat, many authors identified novel foods as a solution to the overpopulation problem (Belluco et al., 2015; Marberg et al., 2017) and world hunger; *the production of cultured meat could address global hunger issues* (Mancini and Antonioli, 2019), with results considering related ethical profiles. Other studies emphasized that cultured meat consumption also favors animal welfare and faces the suffering and slaughtering of farm animals' issues (Mancini and Antonioli, 2019).

6. The consumption of edible insects is part of the arguments put forward in the three previous points (4.1, 4.2, and 5). In fact, several authors emphasized insects' nutritional properties and the possibility to use them as a source of alternative proteins (Lähteenmäki-Uutela and Grmelová, 2016; Dupont and Fiebelkorn, 2020) and the positive effects on human health (Belluco et al., 2013; Fernandez-Cassi et al., 2020). Including such foods in human diets would help to meet world food needs (Menozzi et al., 2017; Aschemann-Witzel and Peschel, 2019; Fernandez-Cassi et al., 2020). The way insects are reared is environmental friendly (Lähteenmäki-Uutela et al., 2017; Menozzi et al., 2017; Tedesco et al., 2019).

7. Regarding risk assessment (Renwick et al., 2003; Goga and Clementi, 2010; van der Fels-Klerx et al., 2010; Worm et al., 2010; Magnuson et al., 2013; Barlow et al., 2015; Steffensen et al., 2018; Verhoeckx et al., 2020), some authors studied this theme by linking it to different profiles as follows: food safety management (Taylor, 2002; de Boer and Bast, 2018; de Boer et al., 2020; Tomasevic et al., 2020), risk management (Van Kleef et al., 2007; Knudsen et al., 2008; Walls et al., 2011), food management (Walls et al., 2011), and safety evaluation in accordance with regulatory requirements (Constable et al., 2007; Magnuson et al., 2013).

Several articles pointed out that consumers' perception of risk assessment is a key element. In fact, despite numerous studies on risks (Goga and Clementi, 2010; van der Fels-Klerx et al., 2010; Walls et al., 2011; Grobe and Rissanen, 2012) and the communication of related outcomes "to consumers, public confidence in risk management has been low" (Frewer et al., 2002, 2004; Van Kleef et al., 2007; Hagemann and Scholderer, 2009). Among the reasons to explain that circumstance there is the "disagreement between technical experts and consumers over the nature of the hazards on which risk assessments should focus." It may be inferred that this lack of confidence in risk assessment, which results from the perception of consumers, would not encourage them to consume the products subject to risk assessment. From this, a negative effect on the novel foods market may be derived, which could not develop widely in this sector (Coppens et al., 2006; Barlow et al., 2015), as highlighted above in the case of lack of consumer propensity (further research in both areas could substantiate these claims).

Similarly, other studies investigated what may reduce the perceived risk by consumers, as this perception might influence and might increase novel foods acceptance (Jang and Kim, 2015).

Some authors underlined that, even though research on food stuffs may *show promising prospect for the use* (Coppens et al., 2006) and the consumption of new food, calls for "safety requirements for food products have impacted a range of product categories" (Coppens et al., 2006), thus arising the need for "risk assessment, risk management, and risk communication" (Coppens et al., 2006).

Indeed, the risk assessment indicates the elements (Barlow et al., 2015) on the basis of which the necessary regulatory measures are established to achieve a good level of safety in the trade of food products (van Putten et al., 2011; Shukla et al., 2014; Formici, 2020). So, the restrictions and rules, that such legislative interventions set, may sometimes impact the trade of food stuff, including novel foods (Knorr, 2002; Grimsby, 2021). In this regard, authors affirm that "legislative decisions are an important factor in the future marketing of food product" (Coppens et al., 2006) as also happens with the so-called superfood (Franco Lucas et al., 2021; Papadaki et al., 2021). In particular, they affirm that some legislation that is relevant in the marketing of functional foods in the European Union (EU) has some practical consequences for manufacturers, marketers, and consumers (Coppens et al., 2006). These considerations on functional foods might also apply to the wider category of novel foods, as well as the previous general affirmation related to food stuffs might also apply to novel foods, since they are a particular subcategory of food products around which safety concerns have been highly discussed (developing further research in both of these areas is preferred to substantiate these claims).

8. On the other hand, with regard to innovation, some authors focused on the advancement of new food supply chains, with the aim of looking at innovative business models (Nosratabadi et al., 2020) in the food industry (Dong et al., 2020). Thus, cultured meat production (Datar and Betti, 2010) is an example of realizing innovation in that it is generated from animal cells taken from a living animal and then grown in a laboratory environment, stimulated and nourished with a nutrient serum (Mancini and Antonioli, 2019). In addition, the controlled environment of the production process and the limited human–animal interaction would allow for improvements regarding both health and safety, thereby reducing the risks of zoonosis and other diseases (Mancini and Antonioli, 2019). Some authors highlighted how understanding the benefits consumers look for in the products (Barrenar et al., 2015) may avoid food innovations' failure rate.

LIMITATION AND FURTHER RESEARCH

While only two keywords (Novel food and Management) guided the present research, and despite the fact that the choices remain subjective, the extraction, utilizing the PRISMA methodology, resulted in a large number of papers: 209. This copious dataset allowed us to deepen the analysis of many aspects including consumer behavior, propensity, and neophobia; strategies to increase the willingness to try novel foods; consumer choices and how these may be influenced by insights into nutritional aspects of novel foods when functional for human health; risk assessment; innovation; environmental sustainability; and social and ethical issues.

Moreover, linking the research on novel food to management perspective led us to exclude other outlooks. Further investigation may address these limitations and explore several connected research areas. Some related studies may dwell on the marginal (or average) propensity to consume and/or on the motivations about consumer preferences expressed among the various types of novel foods offered on the market.

Another aspect that needs to be further explored concerns the determination of the economic costs of the novel food production and its environmental impact, through the conduct of investigations developed with the methods of Life Cycle Costing (LCC) and Life Cycle Assessment (LCA), respectively.

CONCLUSIONS

The present study showed an increasing trend in the number of papers published over the years on the subject of novel foods and management. This insight, together with the amount of author affiliation data, revealed the active interest of the scientific world in this area.

In particular, the number of affiliations showed how a high concentration in Europe, and within this area, universities in the EU countries, emerged. This seemed to be linked to the attention that European political institutions have been paying to novel foods and their management, through the development of regulations in continuous evolution. The aim has been not only to ensure human health safety, but also to grasp the dynamics of technological progress incorporating a set of innovations as well as market needs as a result of consumer behavior toward novel foods.

This led to the consideration that, although the regulations had been changing over the last decade, the scientific literature is active and ready to capture market aspects that may require updates to the current novel food regulations in the future.

The regulatory provisions (Lähteenmäki-Uutela et al., 2021) on the marketing authorization of novel foods, as well as the findings of risk assessment studies to ensure the protection of safety and human health, may influence the development of the market of such products, or its shrinkage, as revealed by the co-occurrence analysis in this paper. The same may apply to aspects related to the perception and behavior, distrust, and food neophobia of consumers. These aspects, in fact, may drive the latter away from the consumption of novel foods and may represent a potential obstacle to trade in this market. Ultimately, studies pointed out several elements and factors that may discourage the propensity to consume and therefore the development of the novel foods market, and for this reason, many surveys focused on finding solutions to overcome these potential obstacles.

A possibility to overcome these obstacles may be represented by the acquisition of awareness by consumers about the existing procedures on risk assessment and food safety on novel foods, supported at the European Union level by a dedicated legislation, as it is possible to learn by reading the many scientific studies in the literature, including those analyzed in this paper.

Similarly, detailed information contained in the numerous novel foods research regarding the nutritional aspects, as well as their consumption advantages for human health along with many suggestions regarding food diets, constitute a range of useful knowledge to overcome the consumers' mistrust, and sometimes even their food neophobia, to orient their choices toward the consumption of novel foods.

Arguments of different trends also emerged. Indeed, the studies on novel foods that analyzed both risk and advantage profiles related to sustainability and innovation underlined elements that may represent incentives to bring the consumer, when aware, toward the use of novel foods. Moreover, the same risk and advantage profiles may contribute to provide useful elements to facilitate the legislator's choices to stimulate the market and to raise consumer awareness.

In this sense, as noted in the discussions highlighted in the present paper, novel foods may therefore represent a possible key to respond to increasingly urgent current global issues. Novel foods, in fact, are harbingers of new ways of design, production, or sale of goods or services that offer an alternative to those that until now have negatively affected the ecosystem and its preservation, as well as human health. Therefore, it is possible to affirm that novel foods may trace a positive economic and social change, in a reciprocal relationship with the developments of scientific research and knowledge. Food and agriculture systems, in particular, may follow alternative pathways (Zarbà et al., 2020a) in order to guarantee food security, nutrition, and sustainability (FAO, 2018).

It is important, therefore, that further research continue to unveil potential existing problems and continue to propose related solutions. It is also valuable to carry out studies on existing products on the market in order to provide insights into the institutions in charge, which could grasp elements in progress, to contribute in outlining a perspective from both a regulatory and economic point of view (Smigic et al., 2019). The importance of further research also lies in the innovative solutions they develop and precisely these solutions may give rise to new market possibilities for novel foods.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

CZ: conceptualization, methodology, investigation, data curation, writing—original draft preparation, and writing—review and editing. GC: conceptualization, methodology, resources, data curation, writing—original draft preparation, writing—review and editing, supervision, and funding acquisition. MH: writing—original draft preparation and writing—review and editing. SB and BP: investigation and writing—original draft preparation. MD'A: conceptualization, resources, writing—original draft preparation, supervision, and funding acquisition. This paper is the result of the full collaboration of all the authors.

FUNDING

This research was supported by Project Economic assessments of the sustainability of agri-food systems, which was funded by UNICT 2016–2018 Piano per la Ricerca. Linea di intervento 2-Seconda annualità P7/WP2 (5A722192141) and Project SicurNaturBio-Sicurezza e attività funzionale su sistemi biologici di estratti naturali da impiegare in formulazioni alimentari, which was funded by the Programma ricerca di ateneo UNICT 2020-22 linea 2 of the University of Catania (Italy) (5A722192153).

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fsufs.2021.799587/full#supplementary-material

REFERENCES

Adegoriola, M. I., Lai, J. H. K., Chan, E. H., and Amos, D. (2021). Heritage building maintenance management (HBMM): a bibliometric-qualitative analysis of literature. *J. Build. Eng.* 42:102416. doi: 10.1016/j.jobe.2021.102416

Agapito, G., Simeoni, M., Calabrese, B., Caré, I., Lamprinoudi, T., Guzzi, P. H., et al. (2018). DIETOS: A dietary recommender system for chronic diseases monitoring and management. *Comput. Methods Programs Biomed.* 153, 93–104. doi: 10.1016/j.cmpb.2017.10.014

Aquaculture Advisory Council (2021). *Farm to Fork Strategy. May 2021 - (AAC 2021-07)*. Rue de l'Industrie 11, 1000 Brussels, Belgium.

Arias, A., González-Rodríguez, S., Vetroni Barros, M., Salvador, R., de Francisco, A. C., Moro Piekarski, C., et al. (2021). Recent developments in bio-based adhesives from renewable natural resources. *J. Clean. Prod.* 314:127892. doi: 10.1016/j.jclepro.2021.127892

Aschemann-Witzel, J., and Peschel, A. O. (2019). How circular will you eat? The sustainability challenge in food and consumer reaction to either waste-to-value or yet underused novel ingredients in food. *Food Qual. Prefer.* 77, 15–20. doi: 10.1016/j.foodqual.2019.04.012

Barlow, S. M., Boobis, A. R., Bridges, J., Cockburn, A., Dekant, W., Hepburn, P., et al. (2015). The role of hazard- and risk-based approaches in ensuring food safety. *Trends Food Sci. Technol.* 46, 176–188. doi: 10.1016/j.tifs.2015.10.007

Barone, A. M., Banovic, M., Asioli, D., Wallace, E., Ruiz-Capillas, C., and Grasso, S. (2021). The usual suspect: How to co-create healthier meat products. *Food Res. Int.* 143:110304. doi: 10.1016/j.foodres.2021.110304

Barrenar, R., Garcia, T., and Camarena, D. M. (2015). An analysis of the decision structure for food innovation on the basis of consumer age. *Int. Food Agribus. Manage. Rev.* 18, 149–170. doi: 10.22004/ag.econ.208499

Belluco, S., Halloran, A., and Ricci, A. (2017). New protein sources and food legislation: the case of edible insects and EU law. *Food Secur.* 9, 803–814. doi: 10.1007/s12571-017-0704-0

Belluco, S., Losasso, C., Maggioletti, M., Alonzi, C., Ricci, A., and Paoletti, M. G. (2015). Edible insects: a food security solution or a food safety concern? *Anim. Front.* 5, 25–30. doi: 10.2527/af.2015-0016

Belluco, S., Losasso, C., Maggioletti, M., Alonzi, C. C., Paoletti, M. G., and Ricci, A. (2013). Edible insects in a food safety and nutritional perspective: a critical review. *Comprehens. Rev. Food Sci. Food Safety* 12, 296–313. doi: 10.1111/1541-4337.12014

Bohm, I., Ferrari, A., and Woll, S. (2017). In-vitro-Fleisch: Eine technische Vision zur Losung der Probleme der heutigen Fleischproduktion und des Fleischkonsums? *Karlsruhe* 20S, 2–20. doi: 10.5445/IR/1000076735

Bruhn, A., Brynning, G., Johansen, A., Lindegaard, M. S., Sveigaard, H. H., Aarup, B., et al. (2019). Fermentation of sugar kelp (saccharina latissima)-effects on sensory properties, and content of minerals and metals. *J. Appl. Phycol.* 31, 3175–3187. doi: 10.1007/s10811-019-01827-4

Coderoni, S., and Perito, M. A. (2021). Approaches for reducing wastes in the agricultural sector. An analysis of Millennials' willingness to buy food with upcycled ingredients. *Waste Manage.* 126, 283–290. doi: 10.1016/j.wasman.2021.03.018

Constable, A., Jonas, D., Cockburn, A., Davi, A., Edwards, G., Hepburn, P., et al. (2007). History of safe use as applied to the safety assessment of novel foods and foods derived from genetically modified organisms. *Food Chem. Toxicol.* 45, 2513–2525. doi: 10.1016/j.fct.2007.05.028

Coppens, P., Da Silva, M. F., and Pettman, S. (2006). European regulations on nutraceuticals, dietary supplements and functional foods: a framework based on safety. *Toxicology* 221, 59–74. doi: 10.1016/j.tox.2005.12.022

Damar, H. T., Bilik, O., Ozdagoglu, G., Ozdagoglu, A., and Damar, M. (2018). Scientometric overview of nursing research on pain management. *Rev. Lat. Am. Enfermagem* 26:e3051. doi: 10.1590/1518-8345.2581.3051

Dardonville, M., Bockstalle, C., and Therond, O. (2021). Review of quantitative evaluations of the resilience, vulnerability, robustness and adaptive capacity of temperate agricultural systems. *J. Clean. Prod.* 286, 125456. doi: 10.1016/j.jclepro.2020.125456

Datar, I., and Betti, M. (2010). Possibilities for an in vitro meat production system. *Innovative Food Sci. Emerg. Technol.* 11, 13–22. doi: 10.1016/j.ifset.2009.10.007

de Boer, A., and Bast, A. (2018). Demanding safe foods – Safety testing under the novel food regulation (2015/2283). *Trends Food Sci. Technol.* 72, 125–133. doi: 10.1016/j.tifs.2017.12.013

de Boer, A., Krul, L., Fehr, M., Geurts, L., Kramer, N., Tabernero Urbieta, M., et al. (2020). Animal-free strategies in food safety & nutrition: what are we waiting for? Part I: Food safety. *Trends Food Sci Technol.* 106, 469–484. doi: 10.1016/j.tifs.2020.10.034

de la Caba, K., Guerrero, P., Trung, T. S., Cruz-Romero, M., Kerry, J. P., Fluhr, J., et al. (2019). From seafood waste to active seafood packaging: an emerging opportunity of the circular economy. *J. Clean. Prod.* 208, 86–98. doi: 10.1016/j.jclepro.2018.09.164.

Diener, M., Erler, K., Hiller, S., Christian, B., and Luckas, B. (2006). Determination of paralytic shellfish poisoning (PSP) toxins in dietary supplements by application of a new HPLC/FD method. *Eur. Food Res. Technol.* 224, 147–151. doi: 10.1007/s00217-006-0302-4

Direction Strategic (2017). Grocers' food for thought over CSR: Discovering if talk turns into effective action. *Strategic Direction* 33, 32–34. doi: 10.1108/SD-03-2017-0046

Dong, X., Wang, J., and Raghavan, V. (2020). Critical reviews and recent advances of novel non-thermal processing techniques on the modification of food allergens. *Crit. Rev. Food Sci. Nutr.* 61, 196–210. doi: 10.1080/10408398.2020.1722942

Dragone, D., and Ziebarth, N. R. (2017). Non-separable time preferences, novelty consumption and body weight: theory and evidence from the East German transition to capitalism. *J. Health Econ.* 51, 41–65. doi: 10.1016/j.jhealeco.2016.11.002

Du, Y., Zhu, G., Cao, J., and Huang, J. (2021). Research supporting malaria control and elimination in china over four decades: a bibliometric analysis of academic articles published in chinese from 1980 to 2019. *Malar. J.* 20:158. doi: 10.1186/s12936-021-03698-y

Dupont, J., and Fiebelkorn, F. (2020). Attitudes and acceptance of young people toward the consumption of insects and cultured meat in Germany. *Food Qual. Prefer.* 85:103983. doi: 10.1016/j.foodqual.2020.103983

EFSA (2021). *Edible Insects: The Science of Novel Food Evaluations*. EFSA Media Relations Office. Available on line: https://www.efsa.europa.eu/en/news/edible-insects-science-novel-food-evaluations (accessed on 1 December 2021).

Esfahani, A. N., Moghaddam, N. B., Maleki, A., and Nazemi, A. (2021). The knowledge map of energy security. *Energy Rep.* 7, 3570–3589. doi: 10.1016/j.egyr.2021.06.001

FAO (2018). *The Future of Food and Agriculture. ALTERNATIVE Pathways to 2050*. Rome: FAO.

FAO (2019). *World Food and Agriculture. Statistical Pocketbook*. Rome: FAO.

FAO (2021). *Looking at Edible Insects From a Food Safety Perspective. Challenges and Opportunities for the Sector*. Rome: FAO.

Fernandez-Cassi, X., Soderqvist, K., Bakeeva, A., Vaga, M., Dicksved, J., Vagsholm, I., et al. (2020). Microbial communities and food safety aspects of crickets (Acheta domesticus) reared under controlled conditions. *J. Insects Food Feed* 6, 429–440. doi: 10.3920/JIFF2019.0048

Formici, G. (2020). Novel Food e insetti per il consumo umano tra interventi legislativi e Corte di giustizia: alla ricerca di un difficile equilibrio. *Rivista di Diritto Alimentare* 14, 48–68. Available online at: http://www.rivistadirittoalimentare.it/rivista/2020-04/FORMICI.pdf

Franco Lucas, B., Costa, J. A. V., and Brunner, T. A. (2021). Superfoods: drivers for consumption. *J. Food Prod. Mark.* 27, 1–9. doi: 10.1080/10454446.2020.1869133

Frewer, L., Lassen, J., Kettlitz, B., Scholderer, J., Beekman, V., and Berdal, K. G. (2004). Societal aspects of genetically modified foods. *Food Chem. Toxicol.* 42, 1181–1193. doi: 10.1016/j.fct.2004.02.002

Frewer, L. J., Miles, S., and Marsh, R. (2002). The GM foods controversy. a test of the social amplification of risk model. *Risk Anal.* 22, 713–723. doi: 10.1111/0272-4332.00062

German Bundestag (2019). *Ausarbeitung: Einzelfragen zu In-vitro-Fleisch (No. WD 5-3000-151/18)*. Deutschland: German Bundestag.

Goga, B. T. C., and Clementi, F. (2010). Safety assurance of foods: risk management depends on good science but it is not a scientific activity. *J. Agric. Biol. Environ. Stat.* 15, 305–313. doi: 10.1023/A:1015757526008

Golbabaei, F., Yigitcanlar, T., Paz, A., and Bunker, J. (2020). Individual predictors of autonomous vehicle public acceptance and intention to use: a systematic review of the literature. *J. Open Innov. Technol. Mark. Complex.* 6:106. doi: 10.3390/joitmc6040106

González-Rubio, J., Navarro-López, C., López-Nájera, E., López-Nájera, A., Jiménez-Díaz, L., Navarro-López, J. D., et al. (2020). A systematic review and meta-analysis of hospitalised current smokers and COVID-19. *Int. J. Environ. Res. Public Health* 17:7394. doi: 10.3390/ijerph17207394

González-Sarrías, A., Combet, E., Pinto, P., Mena, P., Dall'Asta, M., Garcia-Aloy, M., et al. (2017). A systematic review and meta-analysis of the effects of flavanol-containing tea, cocoa and apple products on body composition and blood lipids: exploring the factors responsible for variability in their efficacy. *Nutrients* 9:746. doi: 10.3390/nu9070746

Gouveia, L., Batista, A. P., Sousa, I., Raymundo, A., and Bandarra, N. M. (2008). "Microalgae in novel food products," in *Food Chemistry Research Developments*, ed K. Papadopoulos (Hauppauge, NY: Nova Science Publishers, Inc.).

Grahl, S., Strack, M., Weinrich, R., and Moerlein, D. (2018). Consumer-oriented product development: the conceptualization of novel food products based on spirulina (*Arthrospira platensis*) and resulting consumer expectations. *J. Food Qual.* 2018, 1–11. doi: 10.1155/2018/1919482

Grimsby, S. (2021). New novel food regulation and collaboration for innovation. *Br. Food J.* 123, 245–259. doi: 10.1108/BFJ-02-2020-0154

Grobe, A., and Rissanen, M. E. (2012). Nanotechnologies in agriculture and food - An overview of different fields of application, risk assessment and public perception. *Recent Patents Food Nutr. Agric.* 4, 176–186. doi: 10.2174/2212798411204030176

Hagemann, K. S., and Scholderer, J. (2009). Hot potato: expert-consumer differences in the perception of a second-generation novel food. *Risk Anal.* 29, 1041–1055. doi: 10.1111/j.1539-6924.2009.01229.x

Halpern, B. S., Maier, J., Lahr, H. J., Blasco, G., Costello, C., Cottrell, R. S., et al. (2021). The long and narrow path for novel cell-based seafood to reduce fishing pressure for marine ecosystem recovery. *Fish Fish.* 22, 652–664. doi: 10.1111/faf.12541

Hyde, R., Hartley, S., and Millar, K. (2017). European novel foods policy at a critical juncture: drawing lessons for future novel food governance through a retrospective examination of Regulation 258/97. *Food Drug Law J.* 72, 472–505. Available online at: https://www.jstor.org/stable/26661152

Jacobsen, L. F., Grunert, K. G., Søndergaard, H. A., Steenbekkers, B., Dekker, M., and Lähteenmäki, L. (2014). Improving internal communication between marketing and technology functions for successful new food product development. *Trends Food Sci. Technol.* 37, 106–114. doi: 10.1016/j.tifs.2014.03.005

Jang, S. S., and Kim, D. (2015). Enhancing ethnic food acceptance and reducing perceived risk: the effects of personality traits, cultural familiarity, and menu framing. *Int. J. Hosp. Manage.* 47, 85–95. doi: 10.1016/j.ijhm.2015.03.011

Knorr, D. (2002). High pressure processing for preservation, modification and transformation of foods. *High Pressure Res.* 22, 595–599. doi: 10.1080/08957950212411

Knudsen, I., Søborg, I., Eriksen, F., Pilegaard, K., and Pedersen, J. (2008). Risk management and risk assessment of novel plant foods: concepts and principles. *Food Chem. Toxicol.* 46, 1681–1705. doi: 10.1016/j.fct.2008.01.022

Lähteenmäki-Uutela, A., and Grmelová, N. (2016). European law on insects in food and feed. *Eur. Food Feed Law Rev.* 11, 2–8. Available online at: https://www.jstor.org/stable/43958606

Lähteenmäki-Uutela, A., Grmelová, N., Hénault-Ethier, L., Deschamps, M. -., Vandenberg, G. W., Zhao, A., et al. (2017). Insects as food and feed: Laws of the European Union, United States, Canada, Mexico, Australia, and China. *European Food and Feed Law Review* 12, 22–36. Available online at: https://www.jstor.org/stable/26451416

Lähteenmäki-Uutela, A., Rahikainen, M., Camarena-Gómez, M. T., Piiparinen, J., Spilling, K., and Yang, B. (2021). European Union legislation on macroalgae products. *Aquacult. Int.* 29, 487–509. doi: 10.1007/s10499-020-00633-x

Lai, K., Lim, S., The, P., and Yeap, K. (2016). Characterizing a novel food waste recovery process using an electrostatic separator. *Polish J. Environ. Stud.* 25, 2227–2232. doi: 10.15244/pjoes/62823

Liu, Z., Liu, J., and Osmani, M. (2021). Integration of digital economy and circular economy: current status and future directions. *Sustainability* 13:7217. doi: 10.3390/su13137217

Loeber, A. (2011). The food chain reforged: novel food risk arrangements and the metamorphosis of a metaphor. *Sci. Cult.* 20, 231–253. doi: 10.1080/09505431.2011.563571

Maesano, G., Di Vita, G., Chinnici, G., Gioacchino, P., and D'Amico, M. (2021). What's in organic wine consumer mind? A review on purchasing drivers of organic wines. *Wine Econ. Policy* 10, 3–21. doi: 10.36253/wep-9101

Magnuson, B., Munro, I., Abbot, P., Baldwin, N., Lopez-Garcia, R., Ly, K., et al. (2013). Review of the regulation and safety assessment of food substances in various countries and jurisdictions. *Food Addit. Contam. Part A Chem. Anal. Control. Expo. Risk Assess.* 30, 1147–1220. doi: 10.1080/19440049.2013.795293

Mancini, M. C., and Antonioli, F. (2019). Exploring consumers' attitude towards cultured meat in Italy. *Meat Sci.* 150, 101–110. doi: 10.1016/j.meatsci.2018.12.014

Marberg, A., van Kranenburg, H., and Korzilius, H. (2017). The big bug: the legitimation of the edible insect sector in the Netherlands. *Food Policy* 71, 111–123. doi: 10.1016/j.foodpol.2017.07.008

Martínez-Vázquez, R. M., Milán-García, J., and de Pablo Valenciano, J. (2021). Challenges of the blue economy: evidence and research trends. *Environ. Sci. Eur.* 33:61. doi: 10.1186/s12302-021-00502-1

Martinho, V. J. P. D. (2021). Contributions from literature for understanding wine marketing. *Sustainability* 13:7468. doi: 10.3390/su13137468

Martins, Y., Pelchat, M. L., and Pliner, P. (1997). 'Try it, it's good and it's good for you': effects of taste and nutrition information on willingness to try novel foods. *Appetite* 28, 89–102. doi: 10.1006/appe.1996.0064

Mattick, C. S., Landis, A. E., Allenby, B. R., and Genovese, N. J. (2015). Anticipatory life cycle analysis of in vitro biomass cultivation for cultured meat production in the United States. *Environ. Sci. Technol.* 49, 11941–11949. doi: 10.1021/acs.est.5b01614

McCarthy, B., Kapetanaki, A. B., and Wang, P. (2020). Completing the food waste management loop: Is there market potential for value-added surplus products (VASP)? *J. Clean. Prod.* 256:120435. doi: 10.1016/j.jclepro.2020.120435

Menozzi, D., Sogari, G., Veneziani, M., Simoni, E., and Mora, C. (2017). Eating novel foods: an application of the Theory of Planned Behaviour to predict the consumption of an insect-based product. *Food Qual. Prefer.* 59, 27–34. doi: 10.1016/j.foodqual.2017.02.001

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., and Petticrew, M., et al. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Syst. Rev.* 4:1. doi: 10.1186/2046-4053-4-1

Multineddu, M. (2012). *Le alghe: proprietà e benefici per l'alimentazione, la salute, la bellezza*. Newsletter L'Erboristeria, Maggio. Available online at: https://www.lerboristeria.com/articoli/2012_05_alghe.php (accessed October 27, 2021).

Norouzi, M., Chàfer, M., Cabeza, L. F., Jiménez, L., and Boer, D. (2021). Circular economy in the building and construction sector: a scientific evolution analysis. *J. Build. Eng.* 44:102704. doi: 10.1016/j.jobe.2021.102704

Nosratabadi, S., Mosavi, A., and Lakner, Z. (2020). Food supply chain and business model innovation. *Foods* 9:132. doi: 10.3390/foods9020132

Okumus, B., Dedeoglu, B., B., and Shi, F. (2021). Gender and generation as antecedents of food neophobia and food neophilia. *Tourism Manage. Perspect.* 37:100773. doi: 10.1016/j.tmp.2020.100773

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., et al. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst. Rev.* 372:n71. doi: 10.1136/bmj.n71

Pan, X., Lv, J., Dyck, M., and He, H. (2021). Bibliometric analysis of soil nutrient research between 1992 and 2020. *Agriculture* 11:223. doi: 10.3390/agriculture11030223

Papadaki, A., Kachrimanidou, V., Lappa, I. K., Eriotou, E., Sidirokastritis, N., Kampioti, A., et al. (2021). Mediterranean raisins/currants as traditional superfoods: Processing, health benefits, food applications and future trends within the bio-economy era. *Appl. Sci.* 11, 1605, 1–22. doi: 10.3390/app11041605

Pardo, G., and Zufía, J. (2012). Life cycle assessment of food-preservation technologies. *J. Clean. Prod.* 28, 198–207. doi: 10.1016/j.jclepro.2011.10.016

Park, B.-K., and Cho, M.-S. (2016). Taste education reduces food neophobia and increases willingness to try novel foods in school children. *Nutr. Res. Pract.* 10, 221–228. doi: 10.4162/nrp.2016.10.2.221

Pereira, J., Simões, M., and Silva, J. L. (2019). Microalgal assimilation of vitamin B12 toward the production of a superfood. *J. Food Biochem.* 43:e12911. doi: 10.1111/jfbc.12911

Perrea, T., Krystallis, A., Engelgreen, C., and Chrysochou, P. (2017). Much too new to eat it? Customer value and its impact on consumer-product relationship in the context of novel food products. *J. Product Brand Manage.* 26, 616–630. doi: 10.1108/JPBM-09-2015-0984

Post, M. (2014). Cultured beef: medical technology to produce food. *J. Sci. Food Agricult.* 94, 1030–1041. doi: 10.1002/jsfa.6474

Raboaca, M. S., Bizon, N., and Grosu, O. V. (2021). Optimal energy management strategies for the electric vehicles compiling bibliometric maps. *Int. J. Energy Res.* 45, 10129–10172. doi: 10.1002/er.6503

Ramprasath, V. R., Thandapilly, S. J., Yang, S., Abraham, A., Jones, P. J. H., and Ames, N. (2015). Effect of consuming novel foods consisting high oleic canola oil, barley β-glucan, and DHA on cardiovascular disease risk in humans: the CONFIDENCE (Canola Oil and Fibre with DHA Enhanced) study - protocol for a randomized controlled trial. *Trials* 16:489. doi: 10.1186/s13063-015-1014-5

Renwick, A. G., Barlow, S. M., Hertz-Picciotto, I., Boobis, A. R., Dybing, E., Edler, L., et al. (2003). Risk characterisation of chemicals in food and diet. *Food Chem. Toxicol.* 41, 1211–1271. doi: 10.1016/S0278-6915(03)00064-4

Rumpold, B. A., and Schlüter, O. K. (2013). Nutritional composition and safety aspects of edible insects. *Mol. Nutr. Food Res.* 57, 802–823. doi: 10.1002/mnfr.201200735

Scaffardi, L. (2020). "Novel Food una sfida ancora aperta tra sicurezza alimentare, innovazione e sviluppo sostenibile," in *Cibo e Diritto. Una prospettiva comparata*, editors L. Scaffardi and V. Zeno-Zencovich, Vol. I – II (Roma: TrE-Press), 735–773.

Schlüter, O., Rumpold, B., Holzhauser, T., Roth, A., Vogel, R. F., Quasigroch, W., et al. (2017). Safety aspects of the production of foods and food ingredients from insects. *Mol. Nutr. Food Res.* 61, 1600520. doi: 10.1002/mnfr.201600520

Shukla, S., Shankar, R., and Singh, S. P. (2014). Food safety regulatory model in India. *Food Control* 37, 401–413. doi: 10.1016/j.foodcont.2013.08.015

Sidali, K. L., Pizzo, S., Garrido-Perez, E. I., and Schamel, G. (2019). Between food delicacies and food taboos: a structural equation model to assess Western students' acceptance of Amazonian insect food. *Food Res. Int.* 115, 83–89. doi: 10.1016/j.foodres.2018.07.027

Smigic, N., Djekic, I., Tomic, N., Udovicki, B., and Rajkovic, A. (2019). The potential of foods treated with supercritical carbon dioxide (sc-CO2) as novel foods. *Br. Food J.* 121, 815–834. doi: 10.1108/BFJ-03-2018-0168

Sogari, G., Bogueva, D., and Marinova, D. (2019). Australian consumers' response to insects as food. *Agricult. Basel* 9:108. doi: 10.3390/agriculture9050108

Specht, K., Zoll, F., Schuemann, H., Bela, J., Kachel, J., and Robischon, M. (2019). How will we eat and produce in the cities of the future? From edible insects to vertical farming-a study on the perception and acceptability of new approaches. *Sustainability* 11:4315. doi: 10.3390/su11164315

Spina, D., Vindigni, G., Pecorino, B., Pappalardo, G., D'Amico, M., and Chinnici, G. (2021). Identifying themes and patterns on management of horticultural innovations with an automated text analysis. *Agronomy* 11:1103. doi: 10.3390/agronomy11061103

Steffensen, I.-L., Frolich, W., Dahl, K. H., Iversen, P. O., Lyche, J. L., Lillegaard, I. T. L., et al. (2018). Benefit and risk assessment of increasing potassium intake by replacement of sodium chloride with potassium chloride in industrial food products in Norway. *Food Chem. Toxicol.* 111, 329–340. doi: 10.1016/j.fct.2017.11.044

Szakal, C., Roberts, S. M., Westerhoff, P., Bartholomaeus, A., Buck, N., Illuminato, I., et al. (2014). Measurement of nanomaterials in foods: integrative consideration of challenges and future prospects. *ACS Nano* 8, 3128–3135. doi: 10.1021/nn501108g

Szparaga, A., Tabor, S., Kocira, S., Czerwinska, E., Kubon, M., Plociennik, B., et al. (2019). Survivability of probiotic bacteria in model systems of non-fermented and fermented coconut and hemp milks. *Sustainability* 11:6093. doi: 10.3390/su11216093

Taylor, S. L. (2002). Approaches to the safety assessment of novel foods and novel gene products. *Comments Toxicol.* 8, 241–250. doi: 10.1080/08865140214379

Tedesco, D. E. A., Conti, C., Lovarelli, D., Biazzi, E., and Bacenetti, J. (2019). Bioconversion of fruit and vegetable waste into earthworms as a new protein source: The environmental impact of earthworm meal production. *Sci. Total Environ.* 683, 690–698. doi: 10.1016/j.scitotenv.2019.05.226

Tomasevic, I., Kovačevi,ć, D. B., Jambrak, A. R., Szendr,o, K., Dalle Zotte, A., Prodanov, M., et al. (2020). Validation of novel food safety climate components and assessment of their indicators in Central and Eastern European food industry. *Food Control* 117:107357. doi: 10.1016/j.foodcont.2020.107357

Traynor, M., Moreo, A., Cain, L., Burke, R., and Barry-Ryan, C. (2021). Exploring attitudes and reactions to unfamiliar food pairings: an examination of the

underlying motivations and the impact of culinary education. *J. Culinary Sci. Technol.* 19, 115–137. doi: 10.1080/15428052.2020.1732253

Tuomisto, H. L., and Teixeira De Mattos, M. J. (2011). Environmental impacts of cultured meat production. *Environ. Sci. Technol.* 45, 6117–6123. doi: 10.1021/es200130u

Tuorila, H., and Hartmann, C. (2020). Consumer responses to novel and unfamiliar foods. *Curr. Opin. Food Sci.* 33, 1–8. doi: 10.1016/j.cofs.2019.09.004

Uslu, L., Durmaz, Y., Duyar, H. A., and Bandarra, N. M. (2013). Fatty acids, α-tocopherol and proximate composition of four red macroalgae in the sinop bay (Turkey). *J. Anim. Vet. Adv.* 12, 29–33.

van der Fels-Klerx, H. J., Dekkers, S., Kandhai, M. C., Jeurissen, S. M. F., Booij, C. J. H., and de Heer, C. (2010). Indicators for early identification of re-emerging mycotoxins. *NJAS Wageningen J. Life Sci.* 57, 133–139. doi: 10.1016/j.njas.2010.02.003

Van Eck, N. J., and Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* 84, 523–538. doi: 10.1007/s11192-009-0146-3

Van Eck, N. J., and Waltman, L. (2018). *VOSviewer Manual. 27 April 2018. Manual for VOSviewer version 1.6.8*. Leida: Universiteit Leiden.

van Huis, A., Van Itterbeeck, J., Klunder, H., Mertens, E., Halloran, A., Muir, G., et al. (2013). *Edible Insects: Future Prospects for Food and Feed Security*. Rome: Food and Agriculture Organization of the United Nations. Available online at: https://www.fao.org/3/i3253e/i3253e.pdf (accessed on 1 December 2021).

Van Kleef, E., Houghton, J. R., Krystallis, A., Pfenning, U., Rowe, G., Van Dijk, H., et al. (2007). Consumer evaluations of food risk management quality in Europe. *Risk Anal.* 27, 1565–1580. doi: 10.1111/j.1539-6924.2007.00989.x

van Putten, M. C., Kleter, G. A., Gilissen, L. J. W. J., Gremmen, B., Wichers, H. J., and Frewer, L. J. (2011). Novel foods and allergy regulations and risk-benefit assessment. *Food Control* 22, 143–157. doi: 10.1016/j.foodcont.2010.08.002

Verhoeckx, K., Bogh, K. L., Constable, A., Epstein, M. M., Sommergruder, K. H., Holzhauser, T., et al. (2020). COST Action 'ImpARAS': what have we learnt to improve food allergy risk assessment. A summary of a 4 year networking consortium. *Clin. Trans. Allergy* 10:13. doi: 10.1186/s13601-020-00318-x

Walls, J., Rowe, G., and Frewer, L. (2011). Stakeholder engagement in food risk management: evaluation of an iterated workshop approach. *Public Understanding Sci.* 20, 241–260. doi: 10.1177/0963662509354543

Worm, M., Timmermans, F., Moneret-Vautrin, A., Muraro, A., Malmheden Yman, I. I., Lövik, M., et al. (2010). Towards a European registry of severe allergic reactions: current status of national registries and future needs. *Allergy Eur. J. Allergy Clin. Immunol.* 65, 671–680. doi: 10.1111/j.1398-9995.2010.02332.x

Yue, H., Zhou, P., Xu, Z., Liu, L., Zong, A., Qiu, B., et al. (2020). Effect of low-protein diet on kidney function and nutrition in nephropathy: a systematic review and meta-analysis of randomized controlled trials. *Clin. Nutr.* 39, 2675–2685. doi: 10.1016/j.clnu.2019.11.039

Zanetti, M., Samoggia, A., and Young, J. (2020). Fruit sector strategic management: an exploration of agro-food chain actors' perception of market sustainability of apple innovation. *Sustainability* 12:6542. doi: 10.3390/su12166542

Zarbà, C., Chinnici, G., and D'Amico, M. (2020a). Novel food: The impact of innovation on the paths of the traditional food chain. *Sustainability* 12:555. doi: 10.3390/su12020555

Zarbà, C., Chinnici, G., La Via, G., Bracco, S., Pecorino, B., and D'Amico, M. (2021). Regulatory elements on the circular economy: driving into the agri-food system. *Sustainability* 13:8350. doi: 10.3390/su13158350

Zarbà, C., La Via, G., Pappalardo, G., and Hamam Manal Samir, M. (2020b). The sustainability of novel foods in the transition phase to the circular economy, the trade "algae fit for human consumption" in european union. *AIMS Agricult. Food* 5, 54–75. doi: 10.3934/agrfood.2020.1.54

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's Note: All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.