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ABSTRACT

The CATALYSE project goal is to create a network of food safety actors with the aim to support adoption of knowledge and innovative solutions from farm to fork. The project aims to bridge the gap between innovators, practitioners, policymakers and researchers by facilitating communication among these parties while matching practical needs with innovative solutions. CATALYSE Community of Practice (CoP), will get involved in activities to set priorities for future work, provide food safety education and training, and data related to innovation in food safety, will be made available on an open access platform to support broad communication.

WP3 is in charge of the development of a database of knowledge and innovative solutions for food safety. The main goal of WP3 is to collect, select and translate information about innovation and the most recent scientific knowledge on food safety and create a thematic network through the construction of an “online space” aimed to facilitate access to stakeholders in the field of innovation in food safety and foster their application through the Community of Practice (CoP).

To achieve this goal, all the participants in WP3 (SYREON, UCSC, FFA, UNIAG, AGRO, ANSES) during this first year of project were working to establish methodologies for data collection process on new knowledge and innovative solutions from farm to fork. This deliverable (D3.1), as the first one of the WP3, describes and report methodologies to be used for data collection and selection process, showed with a first pilot about “*novel microbiological detection methods*”.

1 INTRODUCTION

1.1 Scope

The aim of CATALYSE is to consolidate a range of information on new knowledge and innovative solutions into a convenient and straightforward database, which acts as a single source of knowledge for end-users.

The CATALYSE Database will include information and practice-oriented knowledge and innovative solutions from existing databases and resource collection (i.e., journal articles, patents, protocols, guidelines, grey literature, etc.). The database is developed to support key users who play pivotal roles in enabling innovation in food safety: **Researchers,** that develop new technologies and processes, conduct studies, test new products and methods, and provide scientific evidence to support innovation. **Inventors,** who create novel methods or products that can help prevent food hazards, **Entrepreneurs,** they bring new food safety products and technologies to market, to develop and commercialize innovative solutions, **Innovation Facilitators,** they connect researchers, inventors, and other stakeholders in the food ecosystem to collaborate and develop new solutions, **End-Users,** including consumers, restaurants, retailers, and food manufacturers benefit from new products and technologies that help reduce food safety risks, **Food Authorities,** that set standards, monitor compliance, and enforce regulations in food safety and **Policymakers,** who create a supportive environment for food safety innovation by providing funding, regulatory frameworks that encourage innovation, and promoting collaboration among food ecosystem actors. All these actors in the food sector, will be the users of CATALYSE platform, and consequently of the knowledge database.

Finaly, the database will be necessary to integrate and efficiently organize the most relevant information on innovation and scientific knowledge in food safety and will allow stakeholders, to easily access to updated and pertinent translating information. Furthermore, it will contribute to the creation of a thematic network that fosters collaboration among different actors, promoting the exchange of best practices and the advancement of innovative solutions.

For achieving these objectives, we need to define what knowledge, database, novelty and innovative solutions are.

1.2 Definition of Knowledge

The definition of knowledge has been a subject of change due to various philosophical approaches over centuries. Knowledge was in the core of philosophical thinking since ancient times, epistemology, the area of philosophy dealing with the theory of knowledge has a few hundred years of history, and many ideas and concepts were born during these times. Even now, there are several approaches to and notions of knowledge, depending on the scientific domain (especially: philosophy, psychology, neurology, information science).

According to the Oxford Dictionary, knowledge is defined as: "*The fact of knowing or being acquainted with a thing, person, etc.; acquaintance; familiarity gained by experience.*"[1]

Cambridge Dictionary states that knowledge is '*understanding of or information about a subject that you get by experience or study, either known by one person or by people generally*'.[2] Merriam-Webster tells us that knowledge is '*the fact or condition of knowing something with familiarity gained through experience or association*'.[3] Finally, according to Wikipedia, knowledge is '*an awareness of facts, a familiarity with individuals and situations, or a practical skill*'.[4]

According to these definitions, knowledge arises as a result of a process, where facts, information, descriptions or skills are transformed into another level of complexity. It implies that there is a continuity or hierarchy from less structured towards more complex entities, and that there is a difference in the quality between those entities. This is often referred as the DIK (data-information-knowledge) or DIKW (data-information-knowledge-wisdom) pyramid[5].

[1] Knowledge. 2024. In oxforddictionaries.com. Retrieved 8 April 202 from https://www.oed.com/search/dictionary/?scope=Entries&q=knowledge
[2] Knowledge. 2024. In dictionary.cambridge.org. Retrieved 8 April 2024 from https://dictionary.cambridge.org/dictionary/english/knowledge
[3] Knowledge. 2024. In merriam-webster.com. Retrieved 8 April 2024 from https://www.merriam-webster.com/dictionary/knowledge
[4] Knowledge. 2024. In wikipedia.org. Retrieved 8 April 2024 from https://en.wikipedia.org/wiki/Knowledge
[5] Bellinger, G., Castro, D., & Mills, A., 2004. Data, information, knowledge, and wisdom. pdfs.semanticscholar.org. 2004

Russel Ackoff, a systems theorist, classifies the content of our minds into five categories[6]:

1 **Data**: symbols that represent the properties of objects and events.
2 **Information**: consists of processed data, the processing directed at increasing its usefulness.
The difference between data and information is functional, not structural. Provides answers to "who", "what", "where", and "when" questions.
3 **Knowledge**: application of data and information. Answers "how-to" questions
4 **Understanding**: is conveyed by explanations, answers to “why” questions
5 **Wisdom**: evaluated understanding. Wisdom deals with values. It involves the exercise of judgment.

There is a continuous ongoing debate on the various definitions of data, information and knowledge, and many scientists question the linear or hierarchical connection between these concepts. Many concepts define knowledge not as a simple aggregation of information or a higher hierarchical level of this continuum, but arrive to the definition from a connection or process approach: knowledge ‘*is the rules and organizing principles gleaned from data to aggregate it into information*’[7] or ‘*knowledge involves both data and the relationships among data elements or their sets*’[8].

From all of the above, it becomes clear, that the definitions of those concepts are highly dependent on the area of science and the actual objectives of the analysis. Therefore, we have to narrow the definitions to the scope of the current project. As a result of this, the following definitions could be concluded:

- ***Data are measurable, quantifiable facts***, which could be stored.

- ***Information is processed*** (categorized, transformed, etc.) ***data***. The processing is directed at increasing the usefulness to interested stakeholders, to make coherent observations about the world.

- ***Knowledge is obtained via analysis and synthesis of information***, and it contains the data, information and the relationships between all those entities. Rules and organizing principles observed when information is generated from data contributes to knowledge. Knowledge also ***allows for formulating (scientific) questions which lead to further data generation***.

[6] Ackoff, R. L., 1999. From Data to Wisdom. In: Ackoff’s Best. New York, John Wiley & Sons, pp 170 – 172.
[7] Hersh, W. in Zins, C., 2007. Conceptual approaches for defining data, information, and knowledge. J. Am. Soc. Inf. Sci., 58: 479–493. doi:10.1002/asi.20508
[8] Sowell, T. 1996. Knowledge and decisions. New York: Basic Books

Here we have to mention the definition and the role of **metadata**. Metadata is '*data that provides information about other data*'[9] or *'data that defines and describes other data*'.[10] Metadata has a particular and very important role in the information and knowledge generation process, since form an important input to contextualizing the original (raw) data. During this contextualization process the original data are completed with metadata and other data and information, putting the original observations into context. Metadata are not the only source of this additional layer of data and information, but are maybe the most important ones from a practical perspective. The reason for this is that during observation or data collection, usually a lot of metadata are generated as well at the same time, in a close connection to the observations themselves. Therefore, the basis for contextualization already exists in the moment of data generation, no additional data or information source is needed. There are many different types of metadata, like descriptive, structural, administrative, reference, statistical and legal metadata[11], but their role is common: to provide deeper insight into the data which they refer to.

1.3 Definition of a Database

A bibliographic database refers to an organized collection of references to various forms of published digital literature, such as conference proceedings, journals, articles, books, and more. It contains rich subject descriptions like keywords and subject terms, allowing researchers to easily access and retrieve relevant information[1]. A database represents information in the form of data, which are interrelated and organized in a coherent manner. It is designed with intentional redundancy and structured to facilitate efficient use, meeting the information management needs of various users[2]. In summary, the key characteristics of a database can be outlined as follows:

- A collection or set of data.
- Data interrelated and structured.
- Independence of data and processes.
- Support for multiple users and applications.
- Data updating and recovery processes that ensure data integrity, security, and confidentiality.

[9] Metadata. 2024. In merriam-webster.com. Retrieved 8 April 2024 from https://www.merriam-webster.com/dictionary/metadata
[10] Metadata. 2024. In OECD Glossary of statistical terms. Retrieved 8 April 2024 from https://www.oecd-ilibrary.org/economics/oecd-glossary-of-statistical-terms_9789264055087-en
[11] Metadata. 2024. In wikipedia.org. Retrieved 8 April 2024 from https://en.wikipedia.org/wiki/Metadata

1.4 Definition of Novelty

The meaning of new/novel is not straightforward as well. Different knowledge levels exist in different organizations and stakeholders, thus different issues will be novel to a certain food business operators, academic organizations or the authorities.

'New' refers to something recently made, grown, or built, or recently found, invented, or discovered. After a time, something that was 'new' can't be regarded 'new' anymore, and will become 'old'. But how much time should pass for this to happen, what is the time limit for new knowledge/innovation to become old? This time limit may vary according to the subject: different stakeholders (academia or food industry) may perceive different times for a new knowledge/innovation to become old.

For a potential data/information/knowledge collection process, essentially two different approaches could be utilized which will be explained below: a conventional one imitating the human decision-making process, and a systemic approach looking for other patterns of emergence/novelty.

By ***imitating the human decision-making process (Approach 1)***, we mean the preliminary definition of the important concepts of 'new' or 'novel' or 'emerging', etc., in other words the creation of relevant ontologies (terminologies) on which we could base our search strings to parse the knowledge corpus to retrieve the desired new information. This approach could have drawbacks, as it won't find the information where the predefined words are not explicitly mentioned. AI methodologies could assist us in the development of more sophisticated ontologies based on preliminary training on large textual corpuses which have been identified as relevant. Still, this approach would require significant resources for input.

The other approach is the ***identification/definition of other indicators for „novel", which are linked to significant changes in patterns/structures of a system (Approach 2)***. For example, a citation network displaying the citation links between different publications may show those (groups of) publications which are „more important" by having more frequent links (denser parts of the network) to other publications. Investigating the changes of these structures over time may provide us with important signals (indicators) regarding new information being formed, which is worth further deeper investigation.

As a summary to Approaches 1 and 2, a potential way to collect data is searching by keywords, however, due to the breadth and complexity of the food chain this could not be feasible. Elaboration of pre-defined keywords as a hierarchical ontology could be a way forward with the assistance of machine learning methods. The other way is a

systems science perspective by analyzing the current and emerging trends in the food safety domain.

1.5 Definition of Innovative solutions

For this project, it is crucial to define what exactly we consider to be innovations and how we can classify them. This is important because there are several definitions and interpretations depending on the disciplines and sectors involved. E.g., innovation and invention are not the same, and confusing the two definitions is often a source of misunderstanding.

An ***invention*** is a unique or novel device, method, composition, idea or process. An invention may be an improvement upon a machine, product, or process for increasing efficiency or lowering cost. It may also be an entirely new concept. If an idea is unique enough either as a stand-alone invention or as a significant improvement over the work of others, it can be patented. A patent, if granted, gives the inventor a proprietary interest in the patent over a specific period of time, which can be licensed for financial gain.

Innovation is related to, but not the same as, invention. In contrast to invention, innovation is the implementation of a creative idea that specifically leads to greater value or usefulness. That is, while an invention may be useless or have no value yet still be an invention, an innovation must have some sort of value, typically economic.

Surveys of the literature on innovation have found a variety of definitions. In 2009, Baregheh et al.[12] found around 60 definitions in different scientific papers, while a 2014 survey found over 40. Based on their survey, Baragheh et al. attempted to formulate a multidisciplinary definition and arrived at the following:

"*Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace*."

[12] Baregheh, Anahita; Rowley, Jennifer; Sambrook, Sally (4 September 2009). "Towards a multidisciplinary definition of innovation". Management Decision. 47 (8): 1323–1339. doi:10.1108/00251740910984578. ISSN 0025-1747.

We are unlikely to find an exact definition that includes everything, but we can define some of the features that an innovation should have in this case:

- improves food safety: additionally improves safety or is designed to do so
- time scale: only after e.g. 2020
- any type of innovation: product / process / marketing / organizational / report / guidelines / regulations
- metadata assessing preliminary results about its use (scientific results obtained, demonstration, pilot-studies, …)

Classification of innovative solutions

When it comes to innovations, it is not necessarily clear whether they exist only at the level of an idea or whether they are already in industrial application, and this makes a big difference. If we want to assess the maturity of an innovative solution, we have to do it objectively to be comparable.

TRL (Technology Readiness Level) levels are a scale to help understand the state of innovation development (see *Table 1*). These levels range from ideation to practical application and allow to track the development and life cycle of a product or technology. Higher TRL levels indicate that a product or technology is closer to market introduction.

Table 1 TRL levels and its implications

TRL level	Definition
1	Basic principles observed
2	Technology concept formulated
3	Experimental proof of concept
4	Technology validated in laboratory
5	Technology validated in relevant environment (industrially relevant environment in the case of key enabling technologies)
6	Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)

7	System prototype demonstration in operational environment
8	System complete and qualified
9	Actual system proven in operational environment (competitive manufacturing in the case of key enabling technologies; or in space)

TRL was developed at NASA during the 1970s. The European Commission advised EU-funded research and innovation projects to adopt the scale in 2010. TRLs were consequently used in 2014 in the EU Horizon 2020 program. In 2013, the TRL scale was further canonized by the International Organization for Standardization (ISO) with the publication of the ISO 16290:2013 standard. *Annex 1.* provides a more detailed description for easier understanding of TRL levels.

It is important to note that knowledge/innovation level and novelty are somewhat contradicting concepts. Higher knowledge level comes at the cost of novelty: as knowledge grows, its level of novelty decreases, and a very recent set of data/information/knowledge may lack further evidence. This can be seen in the case of innovation levels. Basic principles observed at innovation level of TRL1 are at the highest level of novelty, whereas the actual system proven in operational environment at TRL9 is lower in the level of novelty. A limit shall be set for the quality of knowledge/innovation we aim to collect at a predefined level of novelty.

2 METHODOLOGY

2.1 General approach for gathering 'new knowledge' and 'innovative solutions'

Due to the vast amount of information, a fully manual search and curation of textual information is unrealistic, and an algorithmic solution may be necessary. However, it is worth noting that an algorithmic solution alone would also not be sufficient, the algorithms are suitable for 'narrowing down' the search space and for highlighting key areas or information sources. Thus, a manual expert curation or decision-making system shall still be in place. Therefore, the general approach for gathering 'new knowledge' and 'innovative solutions' is the following:

1. Set up an algorithmic search (both keyword-based and network perspective)
    1.1. Select of sources
    1.2. Define search strings
    1.3. Define inclusion/exclusion criteria
2. Set up a manual curation/interpretation process
3. Define data fields to be collected

In the project, we will separate two phases for building the CATALYSE Database:

A. *Initial database population*: the first search, curation and upload of information. This takes longer time, and needs heavier manual curation.
B. *Continuous update process*: to maintain the database up-to-date, we will need further processes to be in place. These will use more automated tools, and need less manual resources.

2.2 Selection of sources

The establishment of a database requires a structured procedure to ensure the selection of reliable and relevant sources for documents, scientific articles, and other valuable data. Therefore, the first step is selecting which sources would be most suitable for our goal. The selection of the sources is guided by several key criteria, including the quality

and reliability of the information provided, the type of content available (such as scientific articles, news, reports, and datasets specific to Europe), and the functionality of the databases, such as the ability to filter results by specific keywords or categories mandatory for the next steps.

The databases that are selected from a broader list of potential options are detailed in *Table 2*. In this case, the selection process also considers factors such as accessibility, the extent and depth of coverage of each database and the relevance of the content (scientific materials, news on food safety, patents, grey literature) to the specific goals of CATALYSE project.

It is noteworthy that sources associated with legislation are not included for our knowledge database, as we consider that regulations do not typically reflect innovation. However, this decision could be reconsidered in the specific case of new laws or legal reforms.

This systematic evaluation ensure that the databases include in the final selection would not only support comprehensive data collection but also provide a solid base for the later analysis and insights.

Table 2 Selected information sources

Sources	Link	Comments	Inclu-sion
Scientific Papers (only Open Access)			
PubMed	https://pubmed.ncbi.nlm.nih.gov/advanced/	We can use PubMed PMC (open access full texts) as well. API: https://www.ncbi.nlm.nih.gov/home/develop/api/	yes
Scopus	https://www.scopus.com/home.uri	Needs institutional access. API available: https://dev.elsevier.com/sc_apis.html	yes
Science Direct	https://www.sciencedirect.com	Scopus covers this	no
Web of Science	https://www.webofscience.com	Needs institutional access. API available: https://clarivate.com/products/scientific-and-academic-research/research-analytics-evaluation-and-management-solutions/web-of-science-apis/	yes
Google Scholar	https://scholar.google.com	No download or data access option	no
EFSA Scientific opinions	https://efsa.onlinelibrary.wiley.com/journal/18314732	Indexed by PubMed, Scopus and WoS	no
IEEE Xplore	https://ieeexplore.ieee.org/search/advanced	API available: https://ieeexplore.ieee.org/Xplorehelp/administrators-and-librarians/api-portal	yes

JSTOR	https://www.jstor.org/action/showAdvancedSearch	Covers mainly other resources (e.g., images).	no
Core	https://core.ac.uk	Open access, API available: https://core.ac.uk/services/api	yes
Journal of Food Protection	https://www.sciencedirect.com/journal/journal-of-food-protection	Other databases cover it	no
HAL	https://hal.science/	Multidisciplinary open archive for the sharing of published and unpublished research	yes
Food Industry News and Updates			
EMM	https://emm.newsbrief.eu/NewsBrief/search/hu/advanced.html	RSS feed to searches	yes
Food Safety Magazine	https://www.food-safety.com	EMM covers this	no
Food Navigator Europe	https://www.foodnavigator.com	EMM covers this	no
Patents and Intellectual Property			
EPO (European Patent Office)	https://www.epo.org/en	WIPO Patentscope covers this	no
USPTO (United States Patent and Trademark Office)	https://www.uspto.gov	WIPO Patentscope covers this	no
WIPO Patentscope	https://patentscope.wipo.int/search/en/search.jsf	Needs registration for deeper data access. API available: https://wipopearl.wipo.int/en/api	yes
Legislation, Regulations, Food Safety Alerts Documents			
RASFF (Rapid Alert System for Food and Feed)	https://webgate.ec.europa.eu/rasff-window/screen/search	No information on innovations. Let's discuss if we see value in these data	no
EFSA data	https://zenodo.org/communities/efsa-kj	No information on innovations. Let's discuss if we see value in these data	no
EUR-Lex	https://eur-lex.europa.eu/homepage.html	Legislation monitoring services do exist, and these do not provide information on innovations	no
Research Outputs, Data Sharing, Grey Literature			
Cordis	https://cordis.europa.eu/search	RSS available, also API: https://cordis.europa.eu/datalab	yes
Zenodo	https://zenodo.org	API available: https://developers.zenodo.org/#rest-api	yes
OAIster	https://www.oclc.org/en/oaister.html	Advanced search: https://oaister.on.worldcat.org/advancedsearch?queryString=&databaseList=	yes

2.3 Defining search strings

The next step of the workflow require selecting specific keywords to filter and guide the search for articles, documents, and materials related to food safety innovation. This activity is crucial to ensure that the selected sources in previous step, are relevant and consistent with the project's objectives.

It is important to highlight that the thematic chapters of the platform will be defined based on the needs and priorities observe from the responses to the interviews and surveys conducted by WP2 of the CATALYSE project. While the analysis of this data is underway, we decided to proceed with a ***pilot*** on a topic that, from our perspective, could be critical and interesting for the users. In addition, considering the huge theme of food safety, it is important focus on a specific topic that could be of particular interest to the platform's users, such as researchers, innovators, and industry stakeholders. This pilot phase helps us to clearly define the setting of the database and optimize the selection process of materials. In this case, the topic of "***novel microbiological detection methods***" had been selected.

Then, we proceed with identifying keywords related to the most relevant terms, such as "FOOD", "SAFETY", and "INNOVATION," which are essential for guiding the searches and combine the keywords with logical connectors such as **AND**, **OR**, and **NOT**, as well as the used of the asterisk (*) as a wildcard to include word variations. Finally, depending on the source, the number of keywords was adjusted. Below in *Table 3,* the keywords chosen for *novel microbiological detection methods* are specified.

Table 3 KEYWORDS for novel microbiological detection methods.

FOOD	MICROBIOLOGICAL	DETECTION	INNOVATIVE†
food*	microb*	detect*	validat*
dairy	pathogen*	identif*	"performance criteria"
meat	spoil*	analys*	
cheese	contamin*	method*	
milk	infect*	PCR	
egg	bacter*	biosensors	
vegetable*	adenovirus	microfluidics	
cereal*	calicivirus	nanotechnolog*	

fruit*	norovirus	LAMP	
spice*	fungus	"Loop-mediated isothermal amplification"	
legume	virus	biorecogn*	
	Campylobacter	immunosensor	
	Salmonella	KIT	
	Listeria	test	
	Staphylococcus	screening	
	"Bacillus cereus"	assay	
	Pseudomonas		
	"Escherichia coli"		

† In the pilot, innovation was approached through the terms related to validatation, since when publishing new microbiological detection methods, validation against conventional methods is a key part of the process.

In addition, other filters are used to improve the selection process. These include:

- the year of publication (from 2020 onward) to guarantee the inclusion of recent and relevant studies,
- a preference for open-access literature to promote accessibility, and
- the exclusion of review articles, to avoid opinion-based content and focus exclusively on original research, this approach aim to prioritize studies that provide concrete data and innovative solutions.

The detailed search strings and the number of search hits of the pilot are presented in Annex 2.

2.4 Deduplication of Scientific Articles

After filtering keywords across the different selected sources, the results indicate that some scientific articles are duplicated. To address this, the Systematic Review Accelerator (SRA)[13] have been used.

[13] Available at https://sr-accelerator.com

The SRA is free software developed by Bond University, Australia, which includes a validated deduplication tool for faster removal of deduplicate search results. Additionally, SRA offers a word frequency analyser to assist in search strategy development, a search translator to streamline the conversion of searches between databases (e.g., PubMed/Ovid MEDLINE to other major platforms), and a hotkey tool to facilitate article screening within reference management software like EndNote. Although all these tools are included in SRA, in this pilot we only used the deduplicator.

2.5 Expert curation

The involvement of domain expertise in the review and decision process is necessary, if we want to achieve a database rooted in high quality domain knowledge. This is introduced in the process in the point of *relevance screening and critical evaluation of titles and abstracts* of the publications and other information sources compiled after keyword filtering.

For this step, a **list of criteria** was defined (

Table 4), which serve as definition and guidance for expert reviewers to allow for systematic and consistent evaluation of information sources.

For managing the review process, the Rayyan[14] tool had been selected. This tool is particularly beneficial for systematic and literature reviews, enhancing the efficiency of the review process, improving accuracy, and helping maintain a clean and organized review data. Rayyan allow us to focus on the most relevant studies by easily classifying documents as *included* or *excluded,* with the options to add reasons and comments, finally it has a free version, for being accessible to all the reviewers inside the project.

In addition, a Guideline (see Annex 3.) was developed to be sure that all the reviewers follow the same steps and criteria. Each article must be check by two reviewers, if both of them agree in the decision of excluding/including, the article is removed or continue to later stages of the workflow. However, if there is no agreement between the reviewers, a third reviewer should be assigned to decide on the selection.

[14] Available at: https://www.rayyan.ai

Table 4 Inclusion/Exclusion criteria

		Yes/No	Comment
1	Is it about FOOD SAFETY?	Yes - Include No - Exclude	-
2	Is it related to our topic?	Yes - Include No - Exclude	For now, it is **novel microbiological detection methods.** More topics will be included: Pathogenic and spoilage MO, Chemical contaminants, Allergens, Hygienic methods, Detection, Traceability, Packaging, Artificial Intelligence, Nanotechnology.
3	Is it a new contribution/innovation?	Yes - Include No - Exclude	Consider innovation as a method or tool or process or information or product which, regardless of its date of invention and start of use, may **represent a novelty for a specific field** of application or which may bring new knowledge where this does not yet exist.
4	In what phase of application is it?	Ready to use solution-Include High TRL - Include Not application yet - Exclude	If you cannot decide - **Include** and write a note
5	Is it a review?	**No - Include** Yes – Exclude	Excluding all the reviews
6	Author/Institution validation, is the "scientific level" score more than 0?	Yes - Include No - Exclude	Check the journal in the following list: https://kanalregister.hkdir.no/publiseringskanaler/Forside/

*Note: If you cannot decide it – Include and write a note (for all the steps).
*Note: Consider the exclusion criteria in the hierarchical order as they are presented.

The selected articles and documents are uploaded to the platform in a specific format to ensure simplified knowledge and accessible vocabulary. This approach aims to make the content easier to understand for the CATALYSE community and platform users.

2.6 Data extraction

After deciding on the relevance and suitability of the sources, the full texts of the papers and other information are accessed. For extracting the information which later will be published in the CATALYSE Database, a data extraction template has been constructed. The template is presented in *Table 5*.

Table 5 Data extraction template

Data field	Description
1. Title	Title of the paper, patent or other relevant knowledge
2. Year of publication	Publication year, as specified by the source
3. Source	Title of the journal or other source provider
4. DOI/ISBN	Digital Object Identifier (DOI) or International Standard Book Number (ISBN)
5. Author(s)	Authors of the knowledge source
6. Link	Clickable link to the original source
7. Publisher	Journal publisher or data/information provider
8. Author keywords	Keywords provided by the author(s) or journal
9. CATALYSE topic	Keywords or topics defined by CATALYSE by the reviewers
10. Author abstract	Abstract provided by the author(s) in the original source
11. Short summary	Summary generated by a Large Language Model, in various languages

The data will be extracted by the help of Large Language Models (ChatGPT 4o, in the time of writing of this report). The extracted information will be cross-checked by an expert reviewer, to maintain quality and consistency.

2.7 Upload to the CATALYSE platform

All the selected bibliography will be included in CATALYSE platform (that is still under development). We are going to use artificial intelligence tools to help up to simplify the information and understand the principal ideas of each article. In addition, all the information that complements and supports the document will be included (title, year of publication, publisher, doi, authors, keywords, etc.), a short summary of the article and the link to check the whole document in their original database. In *Figure 1.* below, there is an example of how the articles will be presented on the platform, considering that some modifications can be made depending on the type of literature, document, etc.

In addition, search and filtering functionalities will be added to enable easier and more effective navigation for the end users.

Figure 1 Example of presenting a selected document on CATALYSE platform

foods

Article

Growth Control of *Listeria monocytogenes* in Raw Sausage via Bacteriocin-Producing *Leuconostoc carnosum* DH25

Andrea Tönz [1], Susette Freimüller Leischtfeld [1], Marc J. A. Stevens [2], Deborah Glinski-Häfeli [1], Valentin Ladner [1], Corinne Gantenbein-Demarchi [1] and Susanne Miescher Schwenninger [1,*]

Title	**Growth Control of *Listeria monocytogenes* in Raw Sausage Using Bacteriocin-Producing *Leuconostoc carnosum* DH25**
Year of publication	2024
Publisher	*Foods* - MDPI
ISBN/doi	doi.org/10.3390/foods13020298
Authors	Andrea Tönz, Susette Freimüller Leischtfeld , Marc J. A. Stevens, Deborah Glinski-Häfeli, Valentin Ladner, Corinne Gantenbein-Demarchi and Susanne Miescher Schwenninger
Keywords	bacteriocin, leucocin, *Leuconostoc*, *Listeria*, biocontrol, raw sausage
Summary *(simplified terms)*	This study focuses on isolating, identifying, and screening lactic acid bacteria (LAB) from various meat and fish products. A total of 274 LAB strains were screened for their ability to inhibit *Listeria monocytogenes* growth. Using a meat model and raw sausage challenge test, results demonstrated that bacteriocin-producing *Leuconostoc carnosum* DH25 significantly inhibited *L. monocytogenes* growth. The anti-*Listeria* substances showed stability and resistance to temperature and pH changes. Genome sequencing confirmed the absence of virulence factors or antibiotic resistance genes, underscoring the strain's safety. This highlights *Leuconostoc carnosum* DH25's potential as a natural solution to improve food safety and biocontrol in the meat industry.

3 CONTINUOUS AUTOMATIC UPDATE PROCESS

After the initial population of the CATALYSE Database, it is necessary to implement an automatic process for updating the database with new data/articles published in different sources in the future. This is fundamental to ensure that the platform can be continuously actualized with the last and most important knowledge about food safety innovation. For this, multiple automation pipelines will be developed, based on the outcomes of the pilot.

The automatization will use various tools, including KNIME[15], Python[16] and LARGE Language Models (ChatGPT 4o[17], in the time of writing of this report). KNIME is a data analysis platform with a graphical user interface implemented with open-source software. KNIME integrates a whole series of tools in the field of machine learning and data mining and is use in all scientific and industrial fields where data processing is required.

The update process will still use domain expert knowledge at certain critical points of the workflow to ensure consistently high quality content, but will leverage the power of AI and automation to make this process as resource-effective as possible. The process will consist of the following steps.

3.1 Search with pre-filter

The information sources provided in Section of this document, will be embedded in a data accession pipeline. This will enable scheduled automatic access to the information sources and will automatically download the relevant papers and other documents, updating the pre-filtered knowledge corpus in a timely manner.

3.2 Relevance screening and evaluation

Based on the results of the pilot, we will choose from the following approaches for screening, evaluation, and ensuring 'human in the loop' (domain expertise).

a. We will do as during the pilot: manual screening of titles/abstracts, then data extraction with AI from the papers

[15] Available at: https://www.knime.com
[16] Van Rossum, G., & Drake, F. L. (2009). *Python 3 Reference Manual*. Scotts Valley, CA: CreateSpace.
[17] OpenAI (2024). *ChatGPT* (Ver 1.2024.332) [Large language model]. https://chat.openai.com/chat

b. We will use an AI-assisted screening, with the help of ASReview[18]. This is currently the best Machine Learning tool for screening titles and abstract of scientific papers. It provides a priority list of papers based on relevance, which is re-calculated every time we make a decision on relevance. We could save 30-50% of the screening time. Also, there is no need to benchmark or validate it, it is already a published, validated, and widely used technology. The potential drawback is, that we will not screen all the papers, just the ones the software signify as relevant. The next step would be as in case a), so data extraction with AI from the papers.

c. We will use OpenAI ChatGPT for relevance screening. Here, the Custom GPT developed by the consortium would decide on the relevance. In this case, we need to benchmark it with the pilot results. Then, the next step would be different, since we need human experts in the loop: the data extraction would be assisted by AI, but experts would need to validate the relevance of the paper along the extraction more thoroughly.

3.3 Data extraction

We envisage data extraction as now: data will be extracted by the help of Large Language Models (ChatGPT 4o, in the time of writing of this report), and validated by domain experts.

3.4 Further developments

As the knowledge corpus of the CATALYSE Database grows, further information processing and retrieval solutions will be adapted, to ensure better search, filter, conversation, and engagement by and with the community of end users. The current plan is to use *Large Language Model based search and conversation tool* for the end users, using a Retrieval Augmented Generation (RAG) approach.

For complex and knowledge-intensive tasks, it's possible to build a language model-based system that accesses external knowledge sources to complete tasks better. This enables more factual consistency, improves reliability of the generated responses, and helps to mitigate the problem of "hallucination".[19]

[18] van de Schoot, R., de Bruin, J., Schram, R. *et al.* An open source machine learning framework for efficient and transparent systematic reviews. *Nat Mach Intell* **3**, 125–133 (2021). https://doi.org/10.1038/s42256-020-00287-7

[19] https://www.promptingguide.ai/techniques/rag

RAG takes an input and retrieves a set of relevant/supporting documents given the knowledge base (CATALYSE Database). The documents are concatenated as context with the original input prompt and fed to the text generator which produces the final output. This makes RAG adaptive for situations where facts could evolve over time, enabling access to the latest information for generating reliable outputs: the users could have a conversation with the platform about innovative solutions, based on factual, expert-curated knowledge.

4 CONCLUSION

As part of the CATALYSE project, a database of knowledge and innovative solutions is being developed to support the main objective of creating a thematic network. This will be achieved through the construction of an "online space" designed to facilitate access for stakeholders in the field of food safety innovation and to encourage their practical application through the Community of Practice (CoP).

During the first year of the project, WP3 members were focused on defining the most appropriate methodologies for the data collection process concerning new knowledge and innovative solutions.

This deliverable (D3.1) outlines the methodology and workflow for collecting, selecting, and managing information about innovations in food safety and the latest scientific knowledge about it, using a pilot study on the topic of *novel microbiological detection methods* as an example.

In conclusion, it is important to highlight that, for the purposes of this deliverable and to simplify the process, the workflow is explained in general terms. Each database or platform utilized, the type of knowledge or innovative solution (e.g., patents, scientific articles, grey literature), and the specific topic under investigation may involve variations in the methodology for collection and selection.

ANNEXES

Annex 1. Detailed description of TRL levels

1	**Having the idea, the principle, starting basic research**
1.1	Observation of principles, in-depth understanding of materials or processes
2	**Applied research in progress**
2.1	Initial identification of practical applications. Verification of the technological suitability of materials/processes.
2.2	At this stage, applications are still speculative and limited to analytical studies. Publications and other references can be used to support the principle.
2.3	Most of the work is analytical and studies the literature to better understand the scientific aspects.
2.4	The move from TRL1 to TRL2 takes the idea from basic to applied research.
3	**Design of the technology, proof of concept**
3.1	Applied research will continue and early development will be launched. Studies and laboratory measurements are carried out to validate predictions for different components.
3.2	Analytical and laboratory testing to demonstrate expectations for different components of the technology. Perform laboratory tests to measure critical parameters.
3.3	The different components of the technology are validated but will not necessarily be part of the overall system. Modelling and simulation may be needed to complement physical experiments.
4	**Laboratory testing of the alpha prototype, validation of ingredients and procedures.**
4.1	Validation of the alpha prototype components is underway: design, development and laboratory testing of components and/or laboratory testing of procedures.
4.2	The results confirm that both the project objective and the performance indicators are achievable with the designed or modelled system.
4.3	The main components are assembled to demonstrate the functionality of the ensemble.
4.4	TRL 4-6 bridges the gap from scientific research to engineering, bridging the gap between development and demonstration. The main difference between TRL 4 and TRL 5 is that the system is more realistic in terms of application and the environment is closer to the actual operational environment
5	**Small scale prototype, laboratory testing of integrated or semi-integrated system**
5.1	System components and/or procedures are being validated in a relevant environment.
5.2	The main components are already integrated in the system, which has the same configuration as the final system.
5.3	Comparison of laboratory-scale testing and measurements on the prototype.
5.4	The scientific risk is eliminated by the end of TRL 5. Results must be statistically relevant.
6	**Large-scale prototyping, testing and validation. TRL 6 is the start of engineering development.**

6.1	The beta prototype is ready; the system/procedure is demonstrated in an operational environment. The prototype should perform all the tasks of the final system, allowing the cost model to be refined.
6.2	Engineering-scale prototype testing in a relevant operational environment. This is a significant step towards demonstrating technological maturity. The operation of the large-scale prototype and the small-scale prototype must be compared and from this the expected operation of the operational system predicted.
6.3	The main difference between TRL 5 and TRL 6 is that TRL6 brings the project from the laboratory level to the engineering level and allows the size enhancement factors to be defined by which the final system can be designed.
7	**Existence, testing and validation of an integrated prototype system**
7.1	Demonstration of system/procedure in an operational environment, at integrated pilot system level. This represents a significant improvement compared to TRL 6. The design of the system is almost final.
7.2	This section aims to eliminate engineering risk. It is important to follow the scaling as it may reveal a number of engineering and manufacturing difficulties during the transition between TRL6 and TRL 7.
8	**Setting up and running a demonstration system embedded in a commercial environment**
8.1	Proof of system/procedure developed through test and demonstration (pre-commercial demonstration)
8.2	The technology is proven to work in its final form and under the expected conditions. This stage marks the end of system development.
8.3	The real production costs can be determined. Final refinements to the model can be taken into account
9	**Certified system suitable for full commercial deployment**
9.1	Prove the completed system with successful operation in an operational environment
9.2	The final form of the technology has been realised, and it can cope with the full range of operating parameters.
9.3	The focus shifts to statistical process control.

Annex 2. Detailed search strings and search hits

Database	Date of search	Search string	Number of hits	Note
PubMed	10/1/24	((((("food*"[Title/Abstract] OR "dairy"[Title/Abstract] OR "meat"[Title/Abstract] OR "cheese"[Title/Abstract] OR "milk"[Title/Abstract] OR "egg"[Title/Abstract] OR "vegetable*"[Title/Abstract] OR "cereal*"[Title/Abstract] OR "fruit*"[Title/Abstract] OR "spice*"[Title/Abstract] OR "legume"[Title/Abstract]) AND ("microb*"[Title/Abstract] OR "pathogen*"[Title/Abstract] OR "spoil*"[Title/Abstract] OR "contamin*"[Title/Abstract] OR "infect*"[Title/Abstract] OR "bacter*"[Title/Abstract] OR "adenovirus"[Title/Abstract] OR "norovirus"[Title/Abstract] OR "calicivirus"[Title/Abstract] OR "fungus"[Title/Abstract] OR "Campylobacter"[Title/Abstract] OR "Salmonella"[Title/Abstract] OR "Listeria"[Title/Abstract] OR "Staphylococcus"[Title/Abstract] OR "Bacillus cereus"[Title/Abstract] OR "b cereus"[Title/Abstract] OR "Pseudomonas"[Title/Abstract] OR "Escherichia coli"[Title/Abstract] OR "e coli"[Title/Abstract]) AND ("detect*"[Title/Abstract] OR "identif*"[Title/Abstract] OR "analys*"[Title/Abstract] OR "method*"[Title/Abstract] OR "PCR"[Title/Abstract] OR "biosensors"[Title/Abstract] OR "microfluidics"[Title/Abstract] OR "nanotechnolog*"[Title/Abstract] OR "LAMP"[Title/Abstract] OR "Loop-mediated isothermal amplification"[Title/Abstract] OR "biorecogn*"[Title/Abstract] OR "immunosensor"[Title/Abstract] OR "screening"[Title/Abstract] OR "assay"[Title/Abstract] OR "KIT"[Title/Abstract] OR "test"[Title/Abstract]) AND ("validat*"[Title/Abstract] OR "performance criteria"[Title/Abstract]) AND "food safety"[MeSH Terms]) OR "food microbiology"[MeSH Terms]) NOT "review"[Publication Type]) AND 2020/01/01:3000/12/31[Date - Publication]	2172	

Scopus	9/30/24	(TITLE-ABS (food*) OR TITLE-ABS (dairy) OR TITLE-ABS (meat) OR TITLE-ABS (cheese) OR TITLE-ABS (milk) OR TITLE-ABS (egg) OR TITLE-ABS (vegetable*) OR TITLE-ABS (cereal*) OR TITLE-ABS (fruit*) OR TITLE-ABS (spice*) OR TITLE-ABS (legume)) AND (TITLE-ABS (microb*) OR TITLE-ABS (pathogen*) OR TITLE-ABS (spoil*) OR TITLE-ABS (contamin*) OR TITLE-ABS (infect*) OR TITLE-ABS (bacter*) OR TITLE-ABS (adenovirus) OR TITLE-ABS (norovirus) OR TITLE-ABS (calicivirus) OR TITLE-ABS (fungus) OR TITLE-ABS (campylobacter) OR TITLE-ABS (salmonella) OR TITLE-ABS (listeria) OR TITLE-ABS (staphylococcus) OR TITLE-ABS ("Bacillus cereus") OR TITLE-ABS ("b cereus") OR TITLE-ABS (pseudomonas) OR TITLE-ABS ("Escherichia coli") OR TITLE-ABS ("e coli") OR TITLE-ABS (virus)) AND (TITLE-ABS (detect*) OR TITLE-ABS (identif*) OR TITLE-ABS (analys*) OR TITLE-ABS (method*) OR TITLE-ABS (pcr) OR TITLE-ABS (biosensors) OR TITLE-ABS (microfluidics) OR TITLE-ABS (nanotechnolog*) OR TITLE-ABS (lamp) OR TITLE-ABS ("Loop-mediated isothermal amplification") OR TITLE-ABS (biorecogn*) OR TITLE-ABS (immunosensor) OR TITLE-ABS (kit) OR TITLE-ABS (test) OR TITLE-ABS (screening) OR TITLE-ABS (assay)) AND (TITLE-ABS (validat*) OR TITLE-ABS ("performance criteria")) AND PUBYEAR > 2019 AND PUBYEAR < 2026 AND (EXCLUDE (DOCTYPE , "re")) AND (LIMIT-TO (OA , "all"))	2569
Web of Science	9/30/24	TS=(("food*" OR dairy OR meat OR cheese OR milk OR egg OR "vegetable*" OR "cereal*" OR "fruit*" OR "spice*" OR legume) AND ("microb*" OR "pathogen*" OR "spoil*" OR "contamin*" OR "infect*" OR "bacter*" OR adenovirus OR norovirus OR calicivirus OR fungus OR virus OR campylobacter OR salmonella OR listeria OR staphylococcus OR "Bacillus cereus" OR "b cereus" OR pseudomonas OR "Escherichia coli" OR "e coli") AND ("detect*" OR "identif*" OR "analys*" OR "method*" OR pcr OR biosensors OR microfluidics OR "nanotechnolog*" OR lamp OR "Loop-mediated isothermal amplification" OR "biorecogn*" OR immunosensor OR kit OR test OR screening OR assay) AND ("validat*" OR "performance criteria”))	3367

IEEE Xplorer	9/16/24	((food OR "dairy" OR "meat" OR "cheese" OR "milk" OR "egg" OR "vegetable" OR "cereal" OR "fruit" OR "spice" OR "legume") AND ("microb*" OR "pathogen" OR "spoil*" OR "contamination" OR "infect*" OR "bacter*" OR "adenovirus" OR "calicivirus" OR "norovirus" OR "fungus" OR "virus" OR "Campylobacter" OR "Salmonella" OR "Listeria" OR "Staphylococcus" OR "Bacillus cereus" OR "Pseudomonas" OR "Escherichia coli") AND ("detect*" OR "identification" OR "analys*" OR "method" OR "pcr" OR "biosensors" OR "microfluidics" OR "nanotechnology" OR "lamp" OR "Loop-mediated isothermal amplification" OR "biorecognition" OR "immunosensor" OR "kit" OR "test" OR "screening" OR "assay") AND ("validat*" OR "performance criteria"))	21	
OAIster	9/19/24	kw:(food* AND microb* AND detect* AND validat*) OR ti:(food* AND microb* AND detect* AND validat*) AND (yr:2020..2027)	98	
Patentscope†	11/14/24	((((("food" OR "dairy" OR "meat" OR "cheese" OR "milk" OR "egg" OR "vegetable" OR "cereal" OR "fruit" OR "spice" OR "legume") AND ("microbiology" OR "pathogen" OR "spoilage" OR "contaminant") AND ("detection" OR "identification" OR "analysis" OR "method" OR "PCR" OR "biorecognition" OR "sensor" OR "KIT" OR "test" OR "screening" OR "assay" OR "LAMP" OR "microfluidics") AND ("validation" OR "performance criteria"))) AND DG:[01.01.2020 TO 31.12.2024])	7912	This is the number of Global GRANTED patents with relevant IPC codes: A61B, C12M, C12N, C12Q
Patentscope†	11/14/24	((((("food" OR "dairy" OR "meat" OR "cheese" OR "milk" OR "egg" OR "vegetable" OR "cereal" OR "fruit" OR "spice" OR "legume") AND ("microbiology" OR "pathogen" OR "spoilage" OR "contaminant") AND ("detection" OR "identification" OR "analysis" OR "method" OR "PCR" OR "biorecognition" OR "sensor" OR "KIT" OR "test" OR "screening" OR "assay" OR "LAMP" OR "microfluidics") AND ("validation" OR "performance criteria"))) AND DG:[01.01.2020 TO 31.12.2024])	28	This is the number of European GRANTED patents with relevant IPC codes: A61B, C12M, C12N, C12Q

Patentscope[†]	11/14/24	((((("food" OR "dairy" OR "meat" OR "cheese" OR "milk" OR "egg" OR "vegetable" OR "cereal" OR "fruit" OR "spice" OR "legume") AND ("microbiology" OR "pathogen" OR "spoilage" OR "contaminant") AND ("detection" OR "identification" OR "analysis" OR "method" OR "PCR" OR "biorecognition" OR "sensor" OR "KIT" OR "test" OR "screening" OR "assay" OR "LAMP" OR "microfluidics") AND ("validation" OR "performance criteria"))) AND DP:[01.01.2020 TO 31.12.2024])	5851	PCT with relevant IPC codes: A61B, C12M, C12N, C12Q

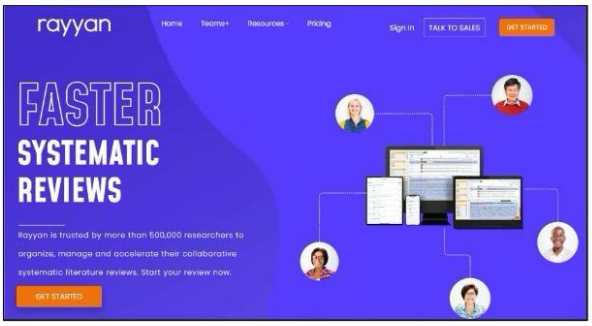
[†] Search for patents needed a shorter search string due to the limitations of the search engine, therefore few keywords were dropped.

Annex 3. Guideline for Title and Abstract Screening with Rayyan

Guideline to use Rayyan:

1- Create an Account

1. Go to Rayyan website (http://www.rayyan.ai).
2. Click on "GET STARTED" and create a free account for sign up.



3. Once logged in "Active Reviews" click on the collaborative group "*Novel microbiological detection methods*".

4. Click on "*Novel microbiological detection methods*", go to the tab Screening and start reviewing. You can sort the articles by different options (e.g. Title, Author, etc.), there is no restriction, it depends on your preferences.

2 - Systematic Review

5. Choose an article, read the title and abstract, then decide whether it is relevant to our topic or not (now it is the 'new microbiological detection methods'). Consider the inclusion/exclusion criteria according to the table below and mark each as "**Include**" or "**Exclude**".

TABLE of Inclusion and Exclusion Criteria

		Yes/No	Comment
1	Is it about FOOD SAFETY?	Yes - Include No - Exclude	-
2	Is it related to our topic?	Yes - Include No - Exclude	For now, it is **novel microbiological detection methods.** More topics will be included: Pathogenic and spoilage MO, Chemical contaminants, Allergens, Hygienic methods, Detection, Traceability, Packaging, Artificial Intelligence, Nanotechnology.
3	Is it a new contribution/innovation?	Yes - Include No - Exclude	Consider innovation as a method or tool or process or information or product which, regardless of its date of invention and start of use, may **represent a novelty for a specific field** of application or which may bring new knowledge where this does not yet exist.
4	In what phase of application is it?	Ready to use solution-Include High TRL - Include Not application yet - Exclude	If you cannot decide - **Include** and write a note
5	Is it a review?	**No - Include** Yes – Exclude	Excluding all the reviews
6	Author/Institution validation, is the "scientific level" score more than 0?	Yes - Include No - Exclude	Check the journal in the following list: https://kanalregister.hkdir.no/publiseringskanaler/Forside/

*Note: If you cannot decide it – Include and write a note (for all the steps).
*Note: Consider the exclusion criteria in the hierarchical order as they are presented.

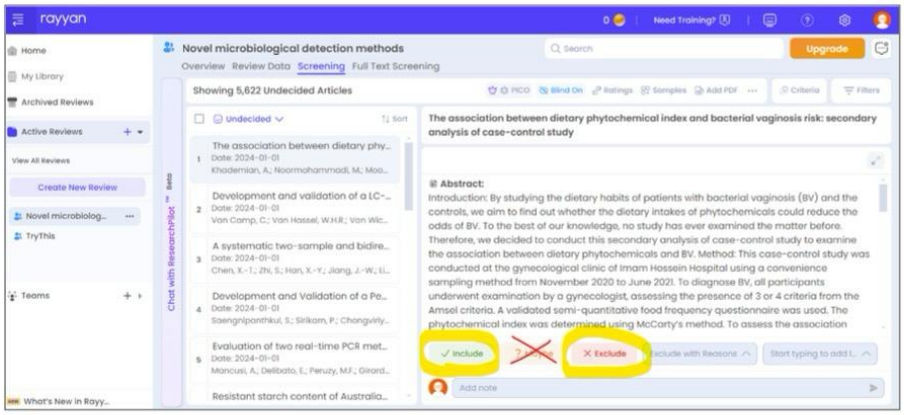
6. **Last step:**
   In case you decide to Exclude an article. Select the reason from the "Exclude with Reasons" list:
   1. Not Food Safety topic
   2. Not about the specific topic (novel detection method, in this case)
   3. Not innovation
   4. Basic-stage research level

5. It is a Review
6. Low scientific level (journal score = 0)

Note: please select the specified reasons provided here (identified in Rayyan by numbers).

Select the relevant exclusion criterion by clicking on "Exclude with Reasons" and the document will be automatically excluded with the selected reason.

Note 1: If the article doesn't meet any of the exclusion criteria, we should include it for further steps. Consider the exclusion criteria in the hierarchical order as they are presented, ie. If you can't exclude a record at the first, then go to the second, etc.

Note 2: Please always make a decision and do not use the "**Maybe**" button. Every article will be screened by two reviewers, in case of conflicts a senior reviewer will decide on the final decision.

7. If you have some comments or you want to explain your decision and point out a detail to others, you have the possibility to write a note. (e.g., "It is not innovation", "Doesn't match with food safety topics ", "Lacks relevant application", etc.).