

This study evaluates EU regulatory documents governing the use of microorganisms in food and feed value chains, focusing on:

- Areas needing modernization
- Evolution of policies (1990–2024)
- Regulatory gaps
- Thematic linkages and keyword trends

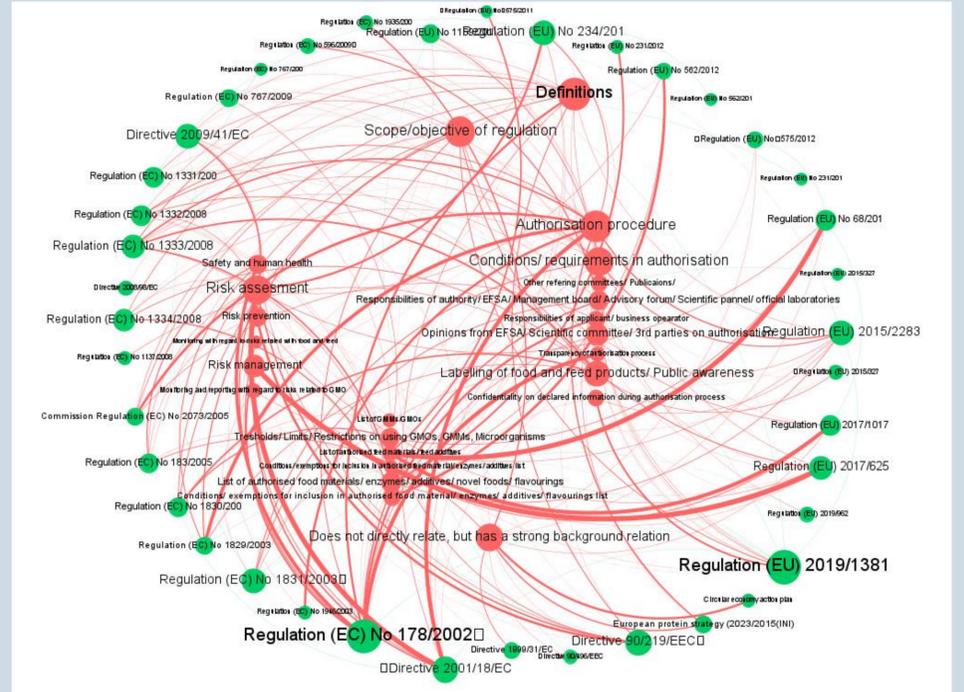


Fig. 5. Visualization of conceptual model

Introduction

The global population hit 8.1 billion in 2024 and is projected to reach 9.6 billion by 2050, increasing pressure on food systems. Climate change, conflicts, and resource overuse worsen food insecurity. In response, the EU promotes sustainable solutions, including microorganism-based food and feed.

Microbial biomass, such as single cell protein and fermented products, offers a promising source of sustainable protein. However, current EU regulations focus heavily on pre-market approval, while post-market monitoring, transparency, and adaptability to innovation remain limited.

Methodology

A quantitative content analysis was used, combining document coding, keyword frequency analysis, and thematic modeling.

Data highlights:

- 7149 keyword mentions → reduced to 1832 meaningful phrases after cleaning
- 25 thematic code groups were derived
- 44 nodes and 205 edges visualized in the network

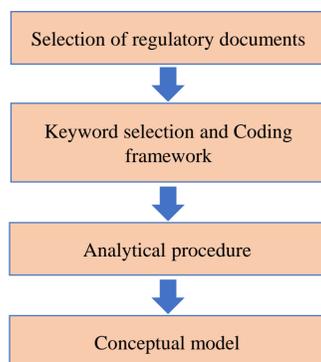


Fig. 1. Workflow of the research

Results and Discussion

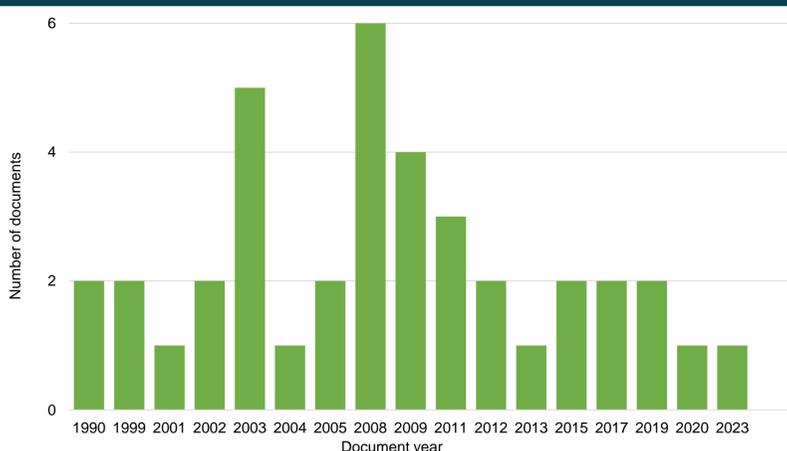


Fig. 2. Summary of selected regulatory documents

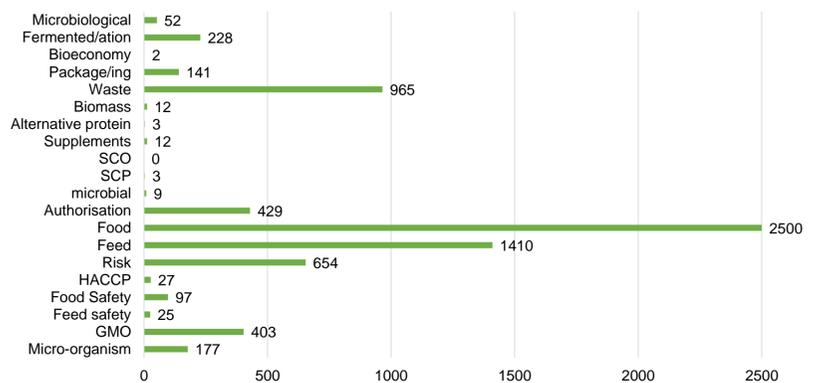


Fig. 3. Summary of keyword frequency analysis

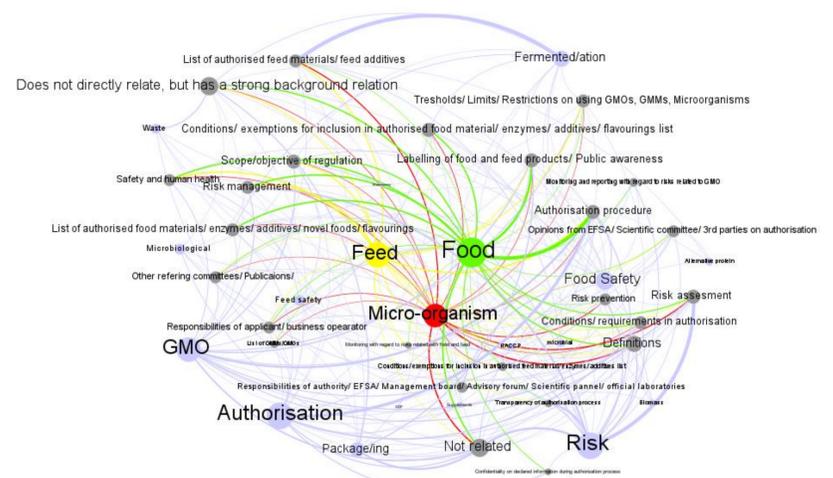


Fig. 4. Relationship of keywords and coding

Conclusion

EU regulations for microorganisms in food and feed are strict and align with international standards, but they struggle to keep pace with rapid innovations like precision fermentation. The case-by-case approval process delays market entry for novel products and limits progress toward sustainability goals.

Key gaps include weak post-market monitoring, outdated transparency, and limited consumer awareness. High compliance costs and complex procedures also challenge SMEs.

To improve, the EU should streamline approvals, adopt technology-neutral frameworks, strengthen post-market oversight, and enhance public trust through clearer communication. Collaboration with global bodies like WHO and FAO can support harmonized, innovation-friendly policies.

ACKNOWLEDGEMENT

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