Chapter

Legal Challenges of Innovative Technologies in the Beverage Sector

Tilman Reinhardt and Lynn Noufaily

Abstract

The chapter provides an overview of legal challenges for innovative beverage technologies in the European Union (EU). We examine food safety and pre-market authorization requirements, focusing on the novel food framework in Regulation (EU) 2015/2283. This framework is relevant for new ingredients, such as cannabidiol (CBD), algal- and plant-based compounds, as well as for upcycled food from side-streams, such as brewer's spent grain, spent yeast, or carbon dioxide (CO_2). It can also apply to innovative production processes, such as ultraviolet-C (UV-C) radiation or alternative fermentations with new microorganisms. In this context, we also explore legal questions on the use of genetically modified microorganisms (GMMs), especially whether trace amounts of recombinant DNA can trigger an application of the framework for genetically modified organisms (GMO) under Regulations (EC) No 1829/2003 and 1830/2003. A second focus of the chapter lies on food information law. We analyze the framework for nutrition and health claims under Regulation (EC) No 1924/2006 and potential pathways, such as plain ingredient labelling for micronutrients. We also examine the emerging regulation of environmental and sustainability claims, such as climate neutrality and upcycled food.

Keywords: food law, novel foods, health claims, green claims, upcycled foods

1. Introduction

Innovation in the beverage sector is shaped by various market developments. Key trends include a rising demand for healthy and functional products, alongside increasing interest in circular economy and upcycling approaches that utilize side-streams, such as brewer's spent grain and fruit pomace. This chapter describes how the legal frameworks on food safety and food information in the European Union (EU) determine how innovative products can be placed on the market. We first analyze pre-market authorization requirements under the frameworks for novel foods (2.1) and genetically modified organisms (GMOs) (2.2). We then look at labelling issues, in particular the regulation on health and nutrition claims (3.1), as well as the emerging framework for sustainability or "green" claims (3.2). We finish by drawing some tentative conclusions (4).

2. Food safety and pre-market authorization

According to the EU's General Food Law (Regulation (EC) No 178/2002), food can generally be put on the market if it is not unsafe. For certain food products, such as additives, novel foods, or GMOs, however, an ex ante authorization is necessary. This can apply to certain new ingredients, such as CBD, algal- or plant-based compounds, or "upcycled" products derived from side-streams (brewer's spent grain, spent yeast, CO_2, etc.), as well as innovative production processes, such as the use of UV-C radiation or "alternative" fermentations with new microorganisms.

2.1 Novel foods

Novel foods in the EU are subject to Regulation (EU) No 2283/2015 (Novel Food Regulation) (hereinafter: NFR). This regulation aims to ensure that new food products and processes do not constitute a risk to human health and safety. It defines novel foods as "*foods not used for human consumption to a significant degree within the Union before 15th May 1997*" in 10 novel food categories.

Novel foods require pre-market authorization before being placed on the market. Only when a novel food is included in the Union List of Novel Foods can it be legally sold across the Union. An authorized novel food reaching the market is as safe as a non-novel food and—unlike GMOs—does not require specific labelling (**Figure 1**).

2.1.1 Authorization procedure

The novel foods authorization process aims to verify that novel foods do not pose safety risks to human health based on available scientific evidence. It ensures that the intended use of novel food does not mislead consumers, especially in cases where a novel food is meant to replace another food and undergoes a significant change in nutritional value. Also, novel foods should not differ in a way that would cause their consumption to be nutritionally disadvantageous for consumers.

The authorization procedure consists of a scientific risk assessment by the European Food Safety Authority (EFSA) and a political risk management decision

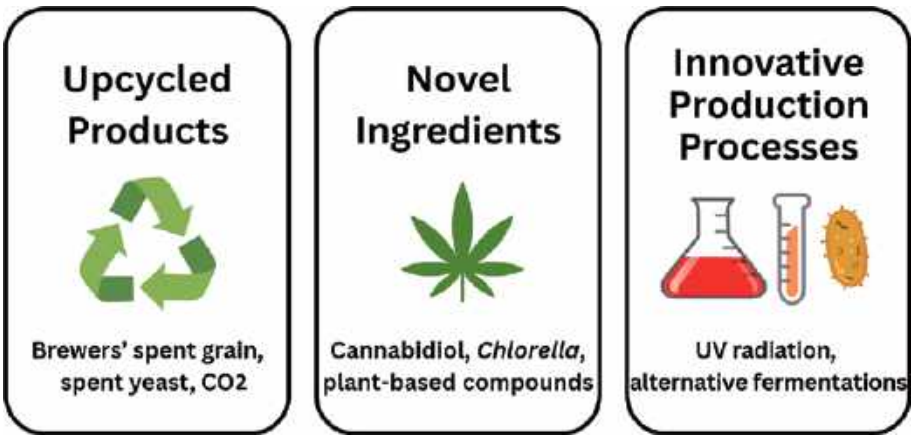

Figure 1.
Examples of novel foods in the beverage industry (own elaboration).

involving the European Commission and Member States' representatives in the Standing Committee on Plants, Animals, Food and Feed (PAFF Committee).

The procedure begins with the production of a dossier, submitted by the applicant through a centralized portal managed by the European Commission. Once the application is received, the dossier is forwarded to the EFSA. The dossier must contain some general information on the applicant, the nature and production processes of the novel food, and a proposal for conditions of use and labelling requirements for the novel food. The dossier must also contain scientific evidence that proves the novel food' s safety. The technical parts of the dossier must be prepared according to the most update guidelines available from the EFSA. On 30 September 2024, the EFSA published the last "Guidance on the Scientific Requirements for an Application for Authorisation of a Novel Food," which applies from 1 February 2025.

When receiving the dossier, the EFSA has 9 months to review it (Article 11 NFR). The Scientific Opinion of the EFSA is based on the data submitted by the applicant and on available scientific evidence. The EFSA does not conduct independent, original studies on the content of the application. The EFSA assessment shall consider whether the product is as safe as a comparable non-novel food, that the composition of the novel food and the conditions of use do not pose a safety risk, and that the consumption of the novel food would not be nutritionally disadvantageous for the consumer.

The EFSA has the power to halt the procedure if more data are needed from the applicant. These delays might be due to the study design, scope, or results. Studies conducted for the purpose of being included in the dossier must be notified to the EFSA before they take place. Failure to do so might result in delays of over 6 months and require a resubmission of the application.

Applicants can receive pre-submission advice from the EFSA, prior to the submission of the application. However, this advice can only concern the generic aspects of the application and not the specific design of studies. It is without prejudice and non-committal as to any subsequent assessment and should not involve EFSA personnel dealing with the assessment of the application.

Once the EFSA publishes its Scientific Opinion, the European Commission has 7 months to prepare a draft implementing regulation authorizing the novel foods taking into consideration the Scientific Opinion, the precautionary principle, and other legitimate factors (Article 12 NFR). The implementing regulation is then voted upon in the PAFF Committee, where Member States' representatives vote on the regulation in a qualified majority voting procedure according to Regulation (EU) No 182/2011.

If the novel food is authorized, the authorization is generic, meaning that every food business operator can place the product on the market, providing that conditions of use and labelling requirements are respected. However, applicants can ask for the application of the "data protection clause," which stipulates that original scientific studies presented by the applicant and deemed necessary for the good outcome of the application cannot be used for the benefit of subsequent applicants for a non-renewable period of 5 years (Article 26 NFR). In practice, this grants a limited market exclusivity, as other applicants would need to submit their own dossier, when willing to place novel food on the market in those 5 years.

The scope of each individual novel food authorization is accurately defined in the implementing regulation authorizing its placement on the market and adding it to the Union List of Novel Foods. The authorizations only cover individual products manufactured under specific condition for specific uses. For example, the novel food "Frozen, dried and powder forms of *Acheta domesticus* (house cricket)" is authorized for use in several food categories, including "beer-like beverages, alcoholic drink

mixes," or "meat analogues" (Commission Implementing Regulation (EU) 2023/5). For "meat analogues," the use of frozen cricket is allowed for a maximum level of 5 g per 100 g but only 0.1 g per 100 g for beer-like beverages.

According to the regulation, the authorization procedure should last no more 17 months. In practice however, due to the EFSA's ability to halt the procedure, the procedure lasts around 31 months on average [1]. The length and the data requirements of the novel food authorization procedure are considered significant challenges for innovators in the EU [2].

2.1.2 National consultation procedures, novel production processes, and qualified presumption of safety

To provide certainty to operators, Article 4 NFR provides for a national consultation procedure to clarify the novel food status and determine whether an authorization is necessary. The consultation involves submitting a detailed dossier to a Member State's competent authority that includes information on the composition, production process, history of use, and intended use of the food. The competent authority evaluates whether the food was consumed to a significant degree within the EU before 15 May 1997. If necessary, the authority may consult other Member States or the European Commission. The results of the national consultation procedure are published by the European Commission on its official Novel Food status Catalog and consultation database.

Regarding beverage innovation, the novel food category in Article 3(2)(a)(vii) NFR can present a particular challenge. It defines as novel any "*food resulting from a production process not used for food production within the Union before 15 May 1997, which gives rise to significant changes in the composition or structure of a food, affecting its nutritional value, metabolism or the level of undesirable substances.*" This provision operates as a broad "catch-all" category [3], meaning that even familiar ingredients and processes may be subject to a novel food authorization.

Case law on this category remains limited. In his opinion in the Court of Justice of the European Union (CJEU) Case C-141/22 (TLL The Longevity Labs GmbH v Optimize Health Solutions mi GmbH and BM), the Advocate General Campos Sánchez-Bordona concluded that that novelty of a processing technology must be assessed specific to the food in question, reinforcing the inherently case-by-case nature of such evaluations.

National Article 4 consultations further illustrate the strict interpretation of production process category. For example, in a 2024 French consultation, UV-C-treated wine was classified as novel—even though the use of UV-C treatment is common in other food sectors—because its application to wine was judged to potentially alter composition or safety. In fact, not a single national consultation procedure related to production process under Article 3(2)(a)(vii) NFR so far concluded that the product in question was not novel.

The category of "novel production process" in Art. 3(2)(a)(vii) NFR could potentially also apply to new fermentation processes. The use of alternative yeasts and other microorganisms has become an important area of innovation, e.g. in the production of alcohol-free beer [4]. New yeast strains are also used to lower the alcohol content of wine in times of climate change and increase aromatic substances such as glycerol [5].

With regard to microorganisms intentionally added to food or feed, the EFSA's Qualified Presumption of Safety (QPS) framework supports the safety assessment [6]. When a microorganism used in a novel food application has been granted QPS status, EFSA generally limits its safety assessment to verifying that the specific

strain complies with the qualifications listed for the species, such as the absence of antimicrobial resistance or toxigenic potential. This can significantly reduce the data requirements and timeline for applicants. However, the QPS list does not replace the novel food authorization process! If a microorganism or the product derived from it has not been used to a significant degree in the EU before 15 May 1997, a full novel food application may still be required.

2.1.3 Examples of novel foods in the beverage industry

Cannabidiol (CBD) has gained prominence in the European food and beverage market following the 2020 CJEU judgment in the Kanavape case (C-663/18), which clarified that CBD extracted from hemp is classified as a narcotic if it has no psychoactive effects. Member States initially took divergent approaches to the regulation of CBD products. In 2022 however, EFSA concluded that CBD is a novel food requiring pre-market authorization. At the same time, it highlighted data gaps concerning hepatotoxicity, gastrointestinal effects, endocrine disruption, and neurological development, and suspended the assessment pending the submission of additional evidence (so called "clock-stop") [7].

Algal ingredients have entered the Union list of authorized novel foods or were classified as non-novel in national Art. 4 consultation procedures. For example, *Chlorella vulgaris*, *Parachlorella kessleri*, and *Auxenochlorella protothecoides* were deemed not novel in Article 4 consultations because they have long-standing use as food supplements in the EU. By contrast, less common species, such as *Scenedesmus acutus* and *Tetraselmis chuii*, have required full novel food authorization before market placement due to insufficient consumption history.

Plant-based compounds like coffee cherry pulp (cascara) and its infusion were authorized as a novel food by Implementing Regulation (EU) 2022/47, permitting its use in non-alcoholic beverages and herbal infusions with mandatory caffeine labelling. Similarly, coffee leaves were approved as a traditional food from a third country via Implementing Regulation (EU) 2020/917, after the Commission verified their safe history of use in non-EU countries.

"Upcycled" products derived from side-streams of the beverage industry can also require a novel food authorization, depending on the concrete production process: partially hydrolyzed protein derived from spent barley (*Hordeum vulgare*) and rice (*Oryza sativa*) was authorized by Implementing Regulation (EU) 2023/2851 based on an application of AB InBev's spin-off EverGrain. Yeast-derived β-*glucans* from *Saccharomyces cerevisiae* has been authorized by Implementing Decision 2011/762/EU under the then-applicable Regulation (EC) No 258/97.

However, as described above, the novelty can depend on the specific production process. Mechanically separated fractions of brewers' spent grain, for example, were assessed to be not novel in a Dutch Article 4 consultation in 2023. Similarly, conventionally extracted yeast proteins have been classified as non-novel, facilitating the emerging market for spent yeast in both traditional products like Marmite and new solutions like Prew:tein from German start-up ProteinDistillery.

An ongoing authorization procedure concerns Solein, a novel protein produced by cultivating a specific strain of hydrogenotrophic bacteria from the genus *Xanthobacter* through fermentation using CO_2, hydrogen, and minerals as substrates. This product, developed by the Finnish company Solar Foods, has already received novel food authorization in Singapore as well as a self-determined GRAS ("*Generally Recognized As Safe*") status in the United States.

2.2 Genetically modified organisms

If genetically modified microorganisms (GMMs) are used in the production of beverages, the framework for GMOs—comprising Regulation (EC) No 1829/2003 on GM food/feed and Regulation (EC) No 1830/2003 on traceability and labelling – may also play a role. GMOs, like novel foods, require pre-market authorization. However, they are also subject to stringent criteria concerning supply chain traceability and consumer labelling.

GMMs are already used in commercial beverage production both in- and outside the EU. Californian company Berkeley Yeast, for example, commercializes genetically modified beer yeast strains that reduce diacetyl formation, leading to shorter fermentation times while improving consistency. Other yeast strains improve aromatic characteristics, for example, by enhancing thiols without adding hops. In wine production, engineered yeasts may be used to reduce ethanol content (a common need in times of climate change) and increase glycerol (although this can to a certain extent already be accomplished with non-engineered yeast, such as Lallemand's Lalvin ICV Okay).

Whether or not the use of GMMs in beverage production triggers an application of the EU GMO framework depends on whether the GMM or its derivatives are present in the final food product or not. Products that are merely produced "with" but not "from" GMOs are outside the scope (cf. Recital 16 of Reg. (EC) No 1829/2003).

In fact, the use of GMMs in food production is already well established, primarily in the form of processing aids [8]. Common examples include enzymes, such as chymosin for cheese production, amylases for baking and brewing, and invertases or pectinases for juice processing. These enzymes are only used as processing aids and are not present in the final food final product, which therefore does not itself qualify as a GMO. GMMs are also used in the production of amino acids and flavor compounds, such as glutamate (E620) for savory seasonings or riboflavin (vitamin B2) for fortification. In these cases, again, only the microbial cell factories are considered to be genetically modified, not the purified ingredient.

In the case of fermented beverages, GMO classification therefore depends on whether filtering or downstream processing completely removes viable yeast cells.

An ongoing debate concerns the question whether trace amounts of recombinant DNA in the final product can trigger a GMO classification. Industry and academic authors argue that trace amounts of recombinant DNA (rDNA) in final products are of no regulatory relevance as long as all GMMs are removed and the DNA is non-functional [9].

The relevance of this discussion goes far beyond the beverage sector and essentially extends to all precision fermentation products. A notable case concerns soy leghemoglobin (LegH Prep), a color additive derived from genetically modified yeast *Komagataella phaffii* Panel. Favorable risk evaluations have been issued by EFSA's Additives and GMO Panels in 2024, explicitly looking at the functionality and evolutionary advantages of recombinant DNA sequences. Still, political stakeholders, for example in the European Parliament, question whether the risk assessment has been sufficiently precautionary and the additive has not been authorized yet.

3. Food information

The legal framework for food information is crucial for marketing innovative beverages to end-consumers. In line with consumer trends, the rules for nutrition

and health claims as well as claims related to the sustainability ("green claims") are of particular relevance.

3.1 Health and nutrition claims

In the EU, health claims are tightly regulated in Regulation (EC) No 1924/2006 nutrition and health claim regulation (NHCR) to prevent misleading messaging and ensure that only scientifically substantiated statements appear on foods and beverages. In Article 2(2)(5) NHCR, a health claim is defined as "*any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents and health*." To be used legally, such claims must be authorized by the European Commission based on a scientific evaluation by EFSA (Articles 13 and 14 NHCR). Applicants must submit a comprehensive dossier with human data to substantiate a cause-effect relationship. All authorized or rejected claims as well as references to scientific opinions and relevant conditions of use are published in the EU Register of Nutrition and Health Claims.

The rules on health claims are interpreted strictly by both national and European courts. For example, generic statements like "relaxing" or "digestible" are usually categorized as health claims. Scientifically sound claims may still be rejected as misleading, as illustrated by the CJEU's Dextro Energy glucose case (C-296/16 P).

Even for authorized claims, the NHCR sets strict standards regarding their presentation on the label. For example, health claims must appear in proximity to the product name and must be worded without altering the scientific or regulatory intent in the EU Register. Article 10 NHCR requires that the label provide mandatory accompanying information, including a statement on the importance of a varied and balanced diet, the quantity of the nutrient or substance required to achieve the claimed effect, and, if relevant, a warning for target populations and on excessive consumption. Any implied health message through graphics or symbols must comply with the same standards (cf. CJEU Case C-524/18).

A transitional exemption from the NHCR applies to certain health claims related to certain botanical substances until the Commission completes their evaluation (Article 28(6) NHCR). In a judgment from 30 April 2025 (C-386/23, Novel Nutriology), the CJEU confirmed not only this exception but also made it clear, that it only applies to botanicals for which claims had been submitted before 2008.

The restrictive legal framework and the fact that beverages often contain only small amounts of certain micronutrients make it challenging to communicate potential functional benefits of innovative beverages. As a result, producers must explore alternative, legally compliant strategies to convey product benefits.

For certain aspects, nutrition claims provide a comparatively easier pathway than health claims. A nutrition claim is defined in Article 2(2)(4) NHCR as "*any claim that states, suggests, or implies that a food has particular beneficial nutritional properties due to the energy (calorific value) it provides, provides at a reduced or increased rate, or does not provide, and/or due to the nutrients or other substances it contains, contains in reduced or increased proportions, or does not contain.*"

Unlike health claims, nutrition claims do not require individual pre-market authorization, but may be used if they comply with the conditions specified in Annex I and Annex II of the NHCR—for example, a 30% reduction in a nutrient for the claim "light," or the presence of a minimum quantity of a nutrient to claim "source of" or "high in." However, all nutrition claims require either an established Nutrient

Figure 2.
Options for the labelling of functional beverages (own elaboration).

Reference Value (NRV) or a specific quantitative threshold explicitly defined in the Regulation's annexes.

Bioactives common in functional beverages—such as flavonoids, polyphenols, xanthohumol, or β-*glucan*—generally lack NRVs and therefore cannot carry content claims like "source of…". However, such ingredients could still appear as factual but neutral ingredient declarations (e.g., "contains beta-glucan") (**Figure 2**).

For developers of innovative functional beverages, this regulatory landscape presents both challenges and opportunities. While health claims are heavily restricted, creatively highlighting ingredients, providing clear dosage information, and engaging in educational outreach can build credibility and align with consumer expectations without violating regulations. A pragmatic, consumer-informed strategy—focusing on transparency rather than formal claims—can foster trust and innovation within the tight legal framework. In fact, empirical consumer studies suggest that consumers do not necessarily value health claims more than precise information on ingredients [10]. Health-conscious consumers and supplement users may already feel confident in their knowledge of which substances they need. In this sense, ingredient transparency and contextual consumer education may play a stronger role than specific claims in stimulating consumer confidence and willingness to buy.

3.2 Sustainability labelling

Consumers are getting more conscious not only about health aspects, but also about the sustainability of food and beverages. In this sense, the relevance of sustainability labelling and climate claims has grown in recent years. Also, the legal framework for "green claims" is undergoing substantial legal evolution.

According to Article 7 of the Food Information Regulation (EU) No 1169/2011, all food information, including voluntary statements, must not mislead consumers about a product's characteristics, effects, or properties, and must be accurate, clear, and not confusing. Article 36 further specifies that voluntary food information must be truthful, unambiguous, and, where relevant, supported by scientific evidence. These rules have been interpreted increasingly strictly by national courts regarding sustainability claims.

Especially climate claims have become a target of nongovernmental organization (NGO) lawsuits in several Member States. In Germany, in a landmark decision on 27 June 2024, the Federal Court of Justice (BGH, Case I ZR 98/23) ruled that advertising a product as "climate-neutral" was unlawful when such a claim is based on a mere "compensation" of emissions, instead of actual in-product emission reductions.

This decision anticipates legislative changes at the EU level. Under the Empowering Consumers for the Green Transition Directive (EmpoCo Directive), Member States must ban unsubstantiated environmental claims, including vague slogans like "green," "climate-friendly," or "carbon neutral," unless supported by clear, objective, publicly available evidence, preferably from independent third-party verification. Starting from 2026, companies will be liable if their sustainability messaging lacks the required transparency or is misleading about future environmental performance or durability.

In its proposal for a Green Claims Directive (COM/2023/166 final), the EU legislator intended to go even further and set uniform EU-wide standards for substantiating environmental claims via independent verification and life-cycle analysis and a mandatory ex ante authorization process. However, negotiations on the proposal stalled in mid-2025 due to concerns about bureaucratic burdens on enterprises.

For products derived from side-streams, the term "upcycling" has become increasingly common in both marketing and scientific literature. So far, no case law or administrative guidance specifically addresses the use of "upcycling" in food or beverage labelling. Potential confusion arises because the term appears to overlap conceptually with the waste hierarchy under EU waste law, which distinguishes waste recovery, recycling, and reuse. However, in the context of food, upcycling does not refer to products legally classified as waste, which would trigger waste-handling obligations and require compliance with "end-of-waste" criteria before entering the food chain. Instead, it is used to describe the valorization of safe, edible side-streams such as brewers' spent grain or yeast into higher-value ingredients for food, beverages, or supplements. It remains to be seen under which conditions such claims may potentially be considered misleading by the courts. In the United States, the term has already gained greater regulatory and market clarity through a voluntary Upcycled Certified™ standard by the Upcycled Food Association.

The most privileged sustainability standard—within current and proposed EU consumer protection frameworks—is the EU organic certification under Regulation (EU) 2018/848: only products certified under this regulation may carry the EU organic logo and use of the term "organic" as well as related terms. Annex I of the EmpCo Directive exempts environmental claims tied to recognized sustainability labels, notably the EU organic logo from being considered generic and potentially misleading. Similarly, the Commission's draft for a Green Claims Directive positions the organic logo as a benchmark for traceable and verified sustainability communication. This regulatory privilege coincides with strong consumer associations between organic certification and sustainability as well as health. In fact, consumer research indicates that many assume that organic products are not only environmentally friendly, but also healthier [11], although health claims are not legally implied by the

designation. As a result, organic certification may offer a powerful, implicit consumer appeal without violating legal restrictions on health and environmental claims.

4. Conclusions

Innovation in the beverage industry is essential to respond to both market demand and policy expectations. A study, conducted by Deloitte in 2025 ("Prost auf die Gesundheit!"), found that 69% of consumers support replacing unhealthy beverages with healthier alternatives, and 61% perceive the selection of healthy beverages on supermarket shelves as insufficient. This highlights the need for portfolio expansion, either through new product development or through reformulation. Indeed, no other product category shows such a pronounced gap between actual consumption and dietary recommendations as beverages [12]. In its 2025 Vision for Agriculture and Food (COM/2025/75 final), the European Commission also acknowledged the key role of the food and beverage industry for achieving the EU's 2040 environmental sustainability targets.

The stringent rules and lengthy authorization procedures for novel foods, however, remain a challenge for food and beverage innovators (2). It remains to be seen whether the EU will adopt a more innovation-friendly approach, as seen in Singapore, Australia, the UK, or the United States, where shorter procedures, pre-authorization tastings, and flexible regulator interactions as well as so-called regulatory sandboxes facilitate faster market access for novel products.

European food law is also strict with respect to health and sustainability labelling. While it is debatable whether these restrictions significantly advance public health objectives, the general trajectory indicates that requirements will continue to tighten. For innovators, however, this must not necessarily be negative. Although simple health or sustainability claims are difficult to make, the framework encourages clean labelling and transparent communication. Successful and compliant strategies could involve highlighting individual metabolites and leveraging consumer education beyond the label. In addition, the EU organic certification—whether justified or not—can function as a powerful combined health and sustainability signifier for the growing health-conscious consumer segment.

Author details

Tilman Reinhardt* and Lynn Noufaily
Faculty of Life Sciences: Food, Nutrition and Health, University of Bayreuth, Germany

*Address all correspondence to: tilman.reinhardt@uni-bayreuth.de

References

[1] Le Bloch J, Rouault M, Langhi C, Hignard M, Iriantsoa V, Michelet O. The novel food evaluation process delays access to food innovation in the European Union. npj Science of Food. 2025;**9**(1):117

[2] Reinhardt T, Monaco A. How innovation-friendly is the EU novel food regulation? The case of cellular agriculture. Future Foods. 2025;**11**:100574

[3] Kostenzer E. Die Novel-Food-VO: Regulierungstechnik und Rechtsprobleme (Doctoral dissertation), Dissertation. Fakultät für Rechtswissenschaften der Leopold-Franzens-Universität Innsbruck. DOI: 10.13140/RG.2.2.27025.76647

[4] Methner Y, Hutzler M, Zarnkow M, Prowald A, Endres F, Jacob F. Investigation of non-saccharomyces yeast strains for their suitability for the production of non-alcoholic beers with novel flavor profiles. Journal of the American Society of Brewing Chemists. 2022;**80**(4):341-355

[5] Garrigós V, Picazo C, Matallana E, Aranda A. Activation of the yeast retrograde response pathway by adaptive laboratory evolution with S-(2-aminoethyl)-L-cysteine reduces ethanol and increases glycerol during winemaking. Microbial cell Factories. 2024;**23**(1):231

[6] Heo S, Kim T, Na HE, Lee G, Park JH, Park HJ, et al. Safety assessment systems for microbial starters derived from fermented foods. Journal of Microbiology and Biotechnology. 2022;**32**(10):1219

[7] Lachenmeier DW, Sproll C, Walch SG. Does cannabidiol (CBD) in food supplements pose a serious health risk? Consequences of the European food safety authority (EFSA) clock stop regarding novel food authorisation. Psychoactives. 2023;**2**(1):66-75

[8] Mallikarjuna N, Yellamma K. Genetic and metabolic engineering of microorganisms for the production of various food products. In: Buddolla V, editor. Recent Developments in Applied Microbiology and Biochemistry [Internet]. Academic Press; 2019. pp. 167-82. DOI: 10.1016/B978-0-12-816328-3.00013-1

[9] Lensch A, Duwenig E, Dederer HG, Kärenlampi SO, Custers R, Borg A, et al. Recombinant DNA in fermentation products is of no regulatory relevance. Food Control. 2022;**141**:109170

[10] Hong X, Li C, Wang L, Gao Z, Wang M, Zhang H, et al. The effects of nutrition and health claim information on consumers' sensory preferences and willingness to pay. Food. 2022;**11**(21):3460

[11] Azizan A, Awal A, Zain WZWM, Hairoman N, Endrini S, Hassan F. Organic food research: Key contributors, research hotspots, and emerging trends. Applied Food Research. 2025;**5**(2):101109

[12] von Philipsborn P. Aktuelles aus der Ernährungspolitik in Deutschland. Adipositas-Ursachen, Folgeerkrankungen, Therapie. 2024;**18**(03):117-122