sustainability

MDPI

Review

Role of Certifications and Labelling in Ensuring Authenticity and Sustainability of Fermented Milk Products

Magdalena Ankiel [1], Michał Halagarda [2,*], Agnieszka Piekara [3], Sylwia Sady [4], Paulina Żmijowska [5], Stanisław Popek [2], Bogdan Pachołek [1], Bartłomiej Jefmański [6], Michał Kucia [5] and Małgorzata Krzywonos [3]

1 Department of Product Marketing, Institute of Marketing Poznań, University of Economics and Business, al. Niepodleglosci 10, 61-875 Poznan, Poland; magdalena.ankiel@ue.poznan.pl (M.A.); bogdan.pacholek@ue.poznan.pl (B.P.)
2 Department of Food Product Quality, Institute of Quality Sciences and Product Management, Krakow University of Economics, Sienkiewcza 5, 30-033 Krakow, Poland; popeks@uek.krakow.pl
3 Department of Process Management, Faculty of Management, Wroclaw University of Economics and Business, Komandorska 118/120, 53-345 Wroclaw, Poland; agnieszka.piekara@ue.wroc.pl (A.P.); malgorzata.krzywonos@ue.wroc.pl (M.K.)
4 Department of Natural Science and Quality Assurance, Institute of Quality Science, Poznań University of Economics and Business, al. Niepodleglosci 10, 61-875 Poznan, Poland; sylwia.sady@ue.poznan.pl
5 Department of International Management, Faculty of Management, Katowice University of Economics, ul. 1 Maja 50, 40-287 Katowice, Poland; paulina.zmijowska@uekat.pl (P.Ż.); mkucia@ue.katowice.pl (M.K.)
6 Department of Econometrics and Computer Science, Faculty of Economics and Finance, Wroclaw University of Economics and Business, Komandorska 118/120, 53-345 Wroclaw, Poland; bartlomiej.jefmanski@ue.wroc.pl
* Correspondence: michal.halagarda@uek.krakow.pl; Tel.: +48-1212937846

Abstract

The increasing demand for sustainably produced food has intensified interest in fermented milk products, such as yoghurt, which combine nutritional value with environmental and ethical considerations. However, the authenticity of sustainability claims in this sector remains contested, raising concerns about consumer trust and regulatory clarity. This review examines the role of certification and labelling in verifying and communicating the sustainability of fermented milk products. The analysis covers regulatory frameworks, consumer perceptions, and the potential of digital tools to improve transparency. Findings highlight inconsistencies in defining key terms such as organic, probiotic, and carbon-neutral, which hinder certification harmonization. Complex labels and allergen declarations can reduce clarity and trust, while overlapping or vague eco-labels risk contributing to consumer confusion and skepticism. Despite this, credible certifications still enhance purchase intent. Modern technologies, including blockchain traceability, interactive QR codes, and digital product passports, offer new ways to reinforce trust, though implementation costs and regulatory gaps remain barriers. This review concludes that effective sustainability communication must integrate robust certification schemes with simplified, transparent messaging. Harmonized standards, improved label design, and consumer education are essential to support informed choices and foster trust in sustainable dairy.

Keywords: sustainable fermented milk products; labelling; certification; product authenticity; customer behavior; innovations in labelling

check for updates

Academic Editor: Francesco Bimbo

Received: 2 August 2025
Revised: 12 September 2025
Accepted: 16 September 2025
Published: 19 September 2025

Citation: Ankiel, M.; Halagarda, M.; Piekara, A.; Sady, S.; Żmijowska, P.; Popek, S.; Pachołek, B.; Jefmański, B.; Kucia, M.; Krzywonos, M. Role of Certifications and Labelling in Ensuring Authenticity and Sustainability of Fermented Milk Products. *Sustainability* **2025**, *17*, 8398. https://doi.org/10.3390/su17188398

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

In recent years, the global food industry has experienced major changes driven by environmental awareness, shifting consumer expectations, and intensified scrutiny of

sustainability practices [1,2]. This trend is especially visible in the dairy sector, where fermented products such as yogurt, kefir, and cultured buttermilk exemplify the link between nutrition and environmentally conscious consumption [3–5]. As consumers increasingly value naturalness, locality, animal welfare, and ecological stewardship, "sustainability" has expanded to include social equity, economic viability, and cultural authenticity, alongside environmental impacts [6,7]. With their historical roots, functional benefits, and low-impact potential, fermented dairy products are central to sustainability debates in academia and policy [8,9]. The growing role of sustainability in consumer choices creates challenges in verifying and communicating claims about authenticity and environmental impact [10]. As food systems become more globalized and technologically complex, the information gap between producers and consumers widens. Certification and labelling have thus become key tools for assuring consumers of production methods, provenance, ingredient integrity, and ecological attributes [11]. By providing third-party verification, they can enhance transparency, trust, and informed purchasing [12]. However, the rapid proliferation of poorly regulated sustainability claims has also generated ambiguity, confusion, and skepticism [13]. This tension is especially evident in the fermented milk sector. Although marketed as traditional, minimally processed, and health-enhancing, these products show highly variable sustainability credentials depending on production scale, sourcing, and post-production modifications [14]. Regulatory definitions of "organic", "probiotic", "carbon-neutral", and "natural" differ across jurisdictions, limiting harmonization and comparability [6]. For example, EU rules restrict the use of "probiotic" without extensive evidence, whereas the United States and Japan permit more flexible labelling [15]. As a result, internationally traded products often display claims interpreted differently across regions and cultures. The effectiveness of labelling depends on consumer literacy, cognitive capacity, and trust in institutions. Studies show that consumers often misinterpret sustainability claims, attributing broad benefits based on single cues—the "halo effect" [16–18]. For example, "organic" or "animal welfare certified" labels may create assumptions of superior nutrition or lower environmental impact without supporting data [19–21]. Conversely, excessive or contradictory labelling can cause cognitive overload, weakening decision-making and fueling skepticism [22]. These effects are further shaped by emotional, cultural, and ethical factors, as products seen as "authentic", "local", or "traditional" may be chosen regardless of actual environmental performance [23]. Credibility is also undermined by discrepancies between labels and product composition. Studies reveal inconsistencies in microbial content, allergen declarations, and nutrient profiles; "probiotic" yogurts often show mismatched microbes, while chemical tests found misreported sugar and undeclared allergens [24,25]. These findings highlight the need to link certification and labelling with rigorous testing, traceability, and transparent audits. Without such safeguards, even well-intentioned labels risk becoming "greenwashing", that is, creating a false impression of a product's environmental impact or benefits and thereby misleading consumers, serving marketing rhetoric rather than empirical truth. Emerging digital technologies are seen as tools to improve transparency, verification, and consumer engagement [26]. Blockchain, QR codes, and digital passports enable real-time data sharing, secure verification, and consumer access [27]. These tools can substantiate certification claims with reliable datasets, support batch-level traceability, and link product attributes to farm practices. For instance, blockchain can record data on feed, antibiotic use, emissions, and cold-chain integrity, accessible through simple interfaces at purchase. Yet adoption faces barriers, including high costs, fragmented infrastructures, regulatory uncertainty, and uneven consumer digital literacy [28]. Communication of sustainability must also go beyond factual data to include narrative, visual, and experiential elements that resonate with consumers [22]. Storytelling about local farmers, animal welfare, or community initiatives reinforces authenticity and

loyalty, while label design must balance compliance, clarity, aesthetics, and emotional impact [29,30]. Research shows that consumers trust certifications from independent public institutions or international standards bodies, especially when supported by clear graphics and simple explanations [31]. This article offers an interdisciplinary review of how certifications and labelling ensure the credibility of sustainability claims in the fermented dairy sector. Drawing on empirical studies, regulatory analyses, consumer research, and technological developments, it examines the structural and communicative dynamics of sustainable labelling. This review situates fermented dairy within the context of responsible production and consumption; analyzes the regulatory landscape, with its disparities and enforcement gaps; and explores consumer perception, focusing on the cognitive, cultural, and ethical factors shaping label interpretation. This article contributes to understanding how certification and labelling can support sustainable dairy systems. It argues that credibility, clarity, and inclusivity are essential to strategies that aim to inform, empower, and align producer and consumer values in today's complex food landscape.

2. Qualitative Document Analysis

To ensure a comprehensive perspective, this study employed a narrative literature review [32–34]. This approach enabled the purposive integration of insights from academic, regulatory, and technological domains relevant to sustainability communication in fermented dairy. The process involved four steps: (1) defining guiding questions and scope, (2) purposive selection of sources, (3) thematic synthesis of the literature, and (4) integration into a cohesive narrative [35].

3. Sustainable Fermented Milk-Based Products: Definitions and Context

3.1. Defining Sustainable Fermented Dairy

A sustainable product is defined as one manufactured through processes that are environmentally benign, socially equitable, and economically viable, while simultaneously upholding high standards of quality and nutritional value. This comprehensive approach necessitates the minimization of adverse impacts on natural ecosystems, the establishment and maintenance of responsible working conditions and welfare across the entire supply chain, and the assurance of sustained economic viability for all involved stakeholders [36].

Fermented milk products (Figure 1) are an important part of daily dietary intake worldwide. Fermentation, as a traditional food processing technique, enhances the nutritional and sensory value of food by breaking down complex organic compounds through biochemical transformations [37]. The use of fermentation with selected starters has long been considered an excellent tool to improve the safety and nutritional/functional properties of food by means of the elimination of microbial contamination, the synthesis of bioactive compounds, detoxification, or the degradation of anti-nutritional compounds while ameliorating their sensory and technological features [38].

In recent years, concurrent with a heightened public awareness of environmental issues and the imperative to mitigate the food industry's ecological footprint, the sustainability of these products has garnered increasing scholarly and public attention. This category encompasses organic products derived from pasture-raised cows, products devoid of chemical additives, and those presented in environmentally conscious packaging. Consumer appreciation for these products stems not only from their organoleptic and health-promoting attributes (particularly probiotic properties) but also from their minimal processing and local provenance [7].

Their progress can be attributed to the global surge in appreciation for functional nutraceutical food and beverage products, including bio-yogurt, kefir, fermented milk,

and a range of probiotic non-dairy equivalents [39]. Their relevance has thus expanded significantly within the discourse of sustainable development [7].

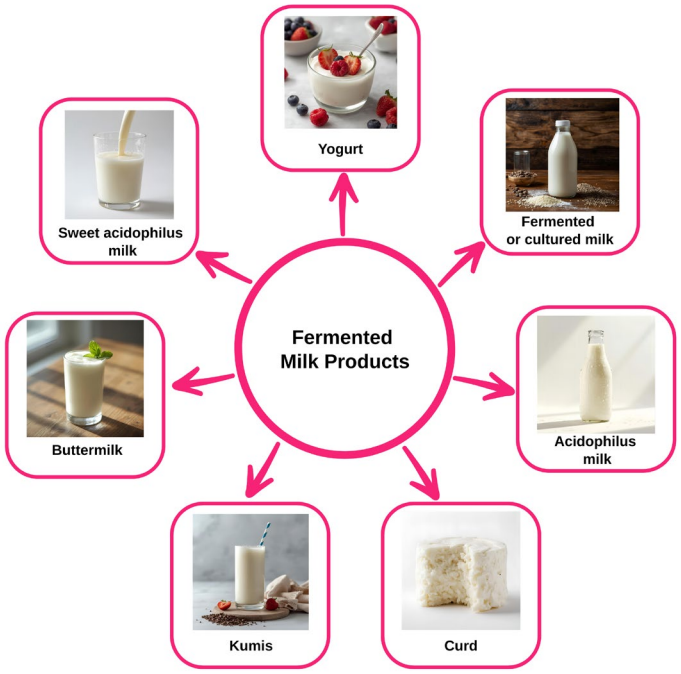


Figure 1. Fermented milk products.

A sustainable milk or dairy fermented product is characterized by its production, processing, and consumption methods, which collectively strive to minimize environmental impact, bolster economic viability for producers, and foster social well-being across the entire supply chain. This comprehensive definition encompasses several key criteria: reducing greenhouse gas emissions, optimizing resource utilization (including feed, water, and energy), ensuring robust animal welfare standards, and fulfilling nutritional requirements through eco-efficient and locally adapted farming and fermentation practices [40–44].

Sustainable development within the dairy industry encompasses a multifaceted array of considerations, including environmental concerns (e.g., greenhouse gas emissions, water consumption, and animal welfare), as well as social and economic dimensions. Nevertheless, a divergence in understanding often exists between producers and consumers regarding these aspects. Consumers frequently interpret sustainability through the lens of health, naturalness, compositional simplicity, or ethical considerations [2,6].

3.2. Consumer Perceptions and Communication Challenges

Products from small-scale producers are often perceived by consumers as inherently more authentic and sustainable, even in the absence of official certifications [45]. While studies, such as that by Otto et al. [46], indicate a growing consumer interest in such products, observed purchasing behaviors do not invariably align with declared values. Prohibitive pricing, limited availability of sustainable options, ambiguous labelling, and a lack of familiarity with or comprehension of certification schemes represent significant deterrents to purchase, notwithstanding general consumer endorsement of the sustainability concept [45,47–49].

It is noteworthy that consumer comprehension of the "sustainable product" concept does not consistently align with interpretations prevalent within the food industry or scientific community [2,6,7]. Although the attributes associated with sustainable products, concerning both the product itself and its packaging, are increasingly valued and sought

after by consumers, their effective communication remains a challenge, often leading to consumer misunderstanding [50]. Furthermore, many product packages inadvertently convey conflicting messages, as textual, graphic, and material elements fail to uniformly communicate sustainability. Consequently, there is an evident necessity to enhance the communication of sustainable product concepts by integrating visual elements harmoniously with the structural and verbal components of packaging [51].

In the context of fermented dairy products, authenticity primarily signifies adherence to declared values such as locality, environmental friendliness, and animal welfare. Effectiveness, conversely, refers to both the product's actual environmental impact and its capacity to influence consumer purchasing decisions [2,11].

3.3. Authenticity, Transparency, and Labelling Strategies

Authenticity is cultivated not solely through certifications but also via brand communication, supply chain transparency, and social engagement. Illustrative activities include emphasizing the local origin of milk, fostering direct relationships with farmers, and supporting educational initiatives. As Futtrup et al. [50] highlight, labels should convey these values in a simple, comprehensible, and visually consistent manner to concurrently maintain authenticity and effectiveness. Consumers generally exhibit a greater propensity to select products bearing labels from public institutions or independent organizations, provided these labels are graphically clear and readily understandable [11].

Unfortunately, research indicates that many labels are either incomprehensible or counter-intuitive, often due to overly complex graphics, a disconnect between pictograms and messages, or illegible text that weakens the overall communication. Norton et al. [47] specifically noted that symbols related to sustainable development are frequently confused with information pertaining to a product's health quality, thereby misleading consumers. Some consumers, for instance, misinterpret labels indicating CO_2 emissions as indicators of a product's health harmfulness [2]. Conversely, labels such as "organic" often create a "halo effect", reinforcing positive associations, including those related to health, even when not always empirically justified [7].

To effectively foster the development of sustainable dairy products, labels ought to be simple, credible, intuitive, and visually consistent [50,51]. A promising strategy is cause-related marketing, which involves labelling that signifies a portion of the product's price supports specific social, environmental, or ethical initiatives. This approach enhances the emotional engagement of consumers who seek value in their purchasing choices but also remain price-sensitive [52].

Ultimately, the authenticity of sustainable food products is fundamentally predicated on transparency within the value chain and the consistency of marketing communication with actual practices. The transparency of processes, from raw material sourcing to distribution, is instrumental in building consumer trust and increasing their willingness to accept higher prices [7].

4. Regulatory Frameworks for Labelling and Certification

Regulatory compliance serves as the fundamental pillar for ensuring the authenticity of dairy products. Labelling is the primary mechanism for conveying critical information to consumers, including ingredients, nutritional composition, manufacturing processes, and, crucially, the product's use-by date. Certifications are crucial in cultivating consumer trust in sustainability claims within the dairy sector, where transparency is essential.

4.1. Institutional and Legal Foundations

Within the European Union, sustainability certifications for fermented milk products operate under the legal framework established and monitored by the European Commission's Directorate-General for Agriculture and Rural Development (DG AGRI) and the Directorate-General for Health and Food Safety (DG SANTE). DG AGRI registers organic operators and protected designations of origin, while DG SANTE coordinates the multi-annual "Health & Food Audits and Analysis" program, which verifies on-site compliance and publishes non-conformity reports, thereby underpinning public trust in label integrity [53]. Day-to-day enforcement is delegated to competent national authorities; for example, the Food Safety Authority of Ireland's nutrient-label audits of retail yogurts illustrate how EU controls translate into market-level action [54].

Globally, certification systems intersect with intergovernmental and federal regulators. The Codex Alimentarius Commission (joint FAO/WHO) sets baseline identity and labelling standards for fermented milks, which many private schemes adopt verbatim, while the International Dairy Federation issues complementary technical bulletins for processors [55]. In the United States, the Department of Agriculture's Agricultural Marketing Service—National Organic Program (USDA AMS-NOP) integrates annual third-party audits with federal rule-making. Longitudinal analysis demonstrates that this structure has tripled certified organic milk output despite higher production costs, although paperwork remains producers' primary compliance burden [56]. Parallel oversight of compositional and allergen labelling rests with the Food and Drug Administration (FDA), whose updates to "healthy" and nutrient-content claims increasingly converge with sustainability messaging requirements. Finally, the International Organization for Standardization (ISO 22005/ISO 22095) codifies traceability principles that national authorities increasingly cite when accrediting dairy certifiers [53]. A multifactorial market study from Ecuador shows that eco-labels do shape attitudes and environmental awareness, but their practical impact on the shopping basket remains limited unless substantiated by additional laboratory evidence confirming product authenticity [57].

4.2. Diversity of Schemes and Market Evidence

Certifications in the fermented-dairy sector represent a multifaceted landscape where ecological, welfare-oriented, climate-focused, geographical-origin, and religious assurances often overlap. Crucially, all these schemes rely on transparent standards and independent auditing to maintain credibility. The USDA Organic program, with its clearly defined rules and regular inspections, exemplifies this approach and is illustrated in Figure 2. This scheme has facilitated a threefold increase in U.S. organic-milk output despite ongoing administrative burdens for producers [56]. A global review of nineteen private sustainability schemes reveals wide variation in mandatory criteria and highlights the inherent tension between credibility, accessibility, and continuous improvement, often referred to as the "devil's triangle" [53].

EU statistics reveal a rapid increase in protected-name (PDO/PGI) dairy products; in Romania alone, the number of certified milk products doubled within a decade, reinforcing narratives of regional authenticity [58]. Life-cycle research further confirms that emission levels per liter of milk vary by over sixty percent between farms [59]. In Indonesia, halal certification significantly boosts the perceived quality of UHT milk, whereas the lesser-known national NKV seal has a weaker effect, illustrating how cultural context shapes the impact of labels [60]. Protected-origin schemes further reinforce narratives of regional authenticity and traditional production methods [58]. Collectively, this evidence suggests that enhanced consumer understanding of label significations increases the likelihood of product choices aligning with their values, thereby incentivizing pro-

ducers to adopt more responsible practices. The three-decade history of USDA Organic demonstrates how clear rules and routine audits have tripled U.S. organic-milk output despite higher production costs, with paperwork remaining the primary compliance burden [56]. While shorter ingredient lists generally improve perceived transparency, experts caution that without unambiguous legal definitions, the term "natural" can invite pseudo-claims [61]. Young consumers in Ecuador report that eco-labels heighten environmental awareness, yet this awareness only translates into purchases when accompanied by credible certification narratives [57].

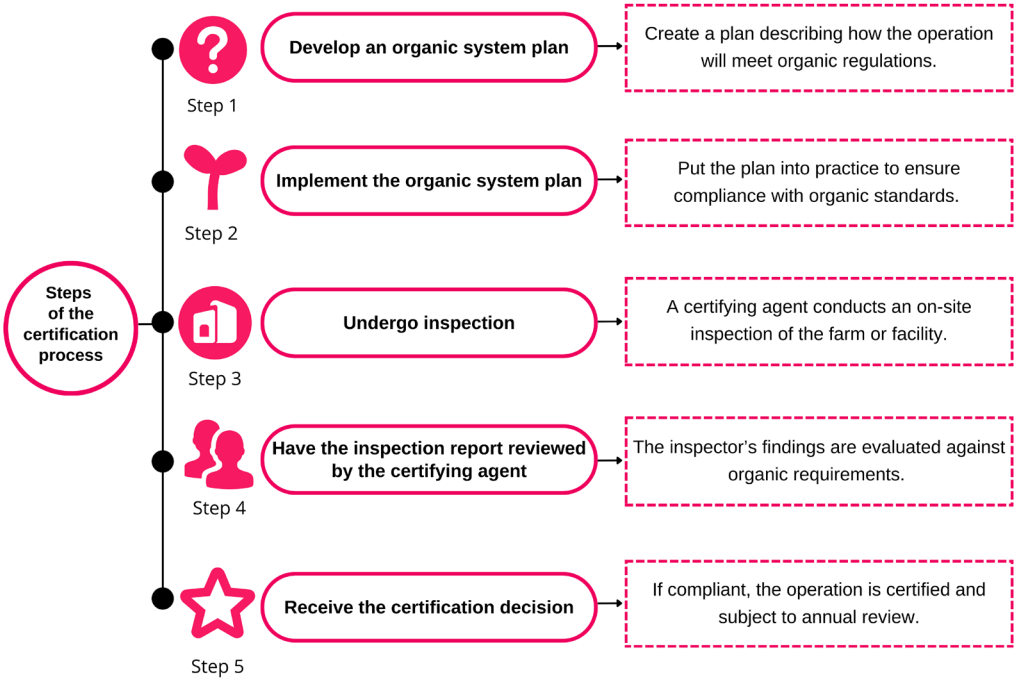


Figure 2. Steps of the USDA organic certification process.

Existing programs, which cover environmental impact, animal welfare, geographic origin, and "clean-label" attributes, vary in scope and rigor, yet all depend on clear, auditable standards to maintain credibility. Life-cycle assessments of 71 Western European dairy farms indicate a greater than 60% spread in the carbon footprint of one liter of milk, emphasizing the importance of precise emission thresholds within certification protocols [53]. A similar variation is documented for PDO Grana Padano, where improved feeding strategies reduced CO_2 output by up to 30% [62]. Italian consumers, meanwhile, express a positive but conditional willingness to pay for explicit "carbon-footprint" labels on dairy products [63].

4.3. Verification, Compliance, and Emerging Standards

Signal quality remains problematic. Interviews with milk buyers in Australia revealed that food shopping is often approached as a task, and complex eco-labels are frequently disregarded in favor of price- and brand-based heuristics, particularly when trust in the certificate's content is low [64]. An e-commerce experiment demonstrated that simple carbon-footprint labels can shift choices toward lower-emission products by 25–37%, although consumers still underestimate the true differences between categories [65].

Crucially, certification does not supersede analytical verification of product composition. DNA analysis of "goat" yogurts detected undeclared bovine or ovine milk in 39.6% of samples, underscoring the necessity of linking labelling schemes with rigorous laboratory testing [66]. A recent review of the clean-label movement shows that short, easily under-

stood ingredient lists can indeed enhance product transparency for shoppers, provided regulators establish clear rules to prevent the misuse of "natural-sounding" wording [61].

Establishing the true composition of yogurts and kefirs now necessitates a combination of classical laboratory tests, modern molecular-biology tools, and systematic audits of digital labels. Advances in metagenomic sequencing indicate that only 37% of dominant microorganisms in analyzed products matched declared bacterial cultures, highlighting the need for comprehensive verification of probiotic strains [67]. Parallel, rapid DNA melting-curve assays effectively detect species substitution; for example, bovine or ovine milk was confirmed in 39.6% of so-called goat yogurts [66].

Conventional chemical analyses remain indispensable: a survey of 200 Irish yogurts revealed that 19% of labels overstated or understated sugar content beyond European tolerances [68]. In the e-commerce environment, this problem is exacerbated. An audit of 12,000 listings found that the full set of mandatory information (nutrition facts, ingredient list, and allergens) was simultaneously available and legible for only 35% of dairy products, while marketing claims dominated the presentation [69].

Finally, a multifactorial market study from Ecuador shows that eco-labels do shape attitudes and environmental awareness, but their practical impact on the shopping basket remains limited unless substantiated by additional laboratory evidence confirming product authenticity [57]. Experiments with carbon-footprint labels indicate that such tags increase the selection of plant-based products (milks and cheeses) yet have not, thus far, led to higher sales of plant-based yogurts [65].

However, recent investigations into fermented milk products frequently reveal that label declarations are often incomplete or inconsistent with the actual product composition. For instance, a cross-sectional analysis of 200 yogurts in Ireland found that 19% of samples exceeded the European tolerance threshold for total sugars [68]. An examination of five commercial kefir brands indicated that 66% overstated viable-cell counts by at least one logarithmic unit [70].

Labelling deficiencies also extend to allergen warnings. Among 768 fermented milk beverages imported into the United Kingdom, only 22.5% displayed correct precautionary allergen labelling (PAL), while 31.2% contained unintended allergens, and 29.2% entirely lacked the required risk statement [71]. In the e-commerce environment, a mere 35.1% of dairy products simultaneously presented accessibly, legibly, and all mandatory label elements—nutrition facts, ingredient lists, and allergen statements—whereas marketing information appeared more frequently than legally mandated data [69]. Non-compliance with certification criteria and, consequently, with labelling requirements, can severely mislead consumers and erode trust in the product.

Taking the above into account, the credibility of certification for fermented dairy products fundamentally rests on three pillars: clear, measurable environmental indicators; unequivocal guarantees of animal welfare; and a simple ingredient list verified through rigorous laboratory testing. Without this triad, even the most sophisticated labels (organic, Eco-Score, or carbon footprint) risk creating a halo effect that misguides consumers. Looking forward, the convergence of digital product passports, AI-driven life-cycle analyses, and harmonized ISO traceability standards promises a unified, globally recognized infrastructure capable of delivering instant, indisputable proof of authenticity for every yogurt or kefir on the shelf.

5. Consumer Perception of Labelling and Certifications

5.1. Labels as Trust Signals and Cognitive Shortcuts

As sustainability considerations play an ever-growing role in the food market, labelling and certifications are emerging as increasingly influential tools in shaping consumer

decision-making. These communicative elements function not only as practical indicators of product attributes but also as trust signals that reduce uncertainty and encourage purchase. Research has shown that consumers are more likely to trust products with clear and accurate labels, and that certifications such as "organic", "sustainable", or "animal-welfare approved" not only enhance credibility but also influence purchasing decisions, as they are perceived as indicators of higher environmental and ethical standards [17,18,72]. Nonetheless, the effectiveness of such labels is closely linked to how they are interpreted. Studies indicate that consumer understanding of sustainability claims is often limited, leading to potential misinterpretations [2]. A prominent example is the "halo effect", where a single favorable label, such as "organic", results in broader assumptions about a product's overall healthiness or environmental impact [2,17,18]. This cognitive shortcut can distort purchasing decisions and suggests that clarity and transparency in labelling are essential to align consumer perceptions with actual product attributes. A similar pattern is observed for the Eco-Score icon: the A–E grade not only alters the perceived environmental friendliness of yogurt but also influences expected palatability and healthfulness, consequently affecting purchase intention [73]. The consumer perspective, however, extends beyond purely environmental aspects. In a survey encompassing five European countries (i.e., Czechia, Spain, Sweden, Switzerland, and the UK), freshness, taste, and animal welfare ranked above carbon footprint or organic origin as primary purchase determinants, even though sustainability labels themselves were regarded as "helpful". Across five European countries, animal welfare logos are rated as the most "helpful" cue when purchasing milk or yogurt, surpassing environmental signals [54]. In Indonesia, halal certification, combined with a national quality mark, significantly enhances perceived dairy quality [60].

Moreover, the effectiveness of these communicative tools is strongly linked to consumer trust. Labels supported by independent, third-party certifications are often perceived as more credible than those created by the producers themselves. However, the proliferation of eco-labels and the lack of standardized criteria across countries can generate confusion and undermine consumer confidence, ultimately reducing the intended persuasive impact [72,74].

This issue is relevant in the context of dairy products, including fermented milk-based products, which are increasingly positioned as sustainable choices. While consumers increasingly expect information on sustainability [75], understanding the messages conveyed on packaging remains challenging [76]. In the case of dairy products, even though labels may refer to important aspects such as local sourcing, animal welfare, or environmental impact, their interpretation is not always straightforward [9]. Moreover, as shown in recent reviews, consumers often confuse terms like "carbon neutral" or "sustainably sourced", especially when such claims are presented without accompanying visual cues or verification references [2]. As a result, the effectiveness of labelling in this category depends not only on clarity and accuracy, but also on the ability to communicate product-specific sustainability aspects in a way that is meaningful and accessible to consumers. This challenge becomes more apparent when traditional dairy products are evaluated alongside plant-based alternatives. Marketing narratives surrounding plant-based products frequently emphasize reduced environmental impact, shaping consumer perceptions even when life-cycle analyses suggest a more nuanced comparison. As shown by Schiano et al. [7], many consumers struggle to understand sustainability-related terms and often rely on intuitive associations rather than informed assessments. This is particularly relevant in international markets, where cultural context further shapes label interpretation. For instance, Jin et al. [72] found that UK consumers tend to integrate environmental considerations into their general purchasing mindset more consistently than Chinese consumers. Such findings emphasize the

importance of tailoring communication strategies to the specific informational needs and cultural expectations of different consumer segments.

5.2. Cultural, Emotional, and Generational Differences

Consequently, dairy producers face growing pressure to clearly and credibly communicate their own sustainability credentials, including local sourcing, biodiversity preservation, and ethical animal husbandry. In this context, labelling must serve not only as a source of information but also as a strategic communication tool that addresses misconceptions and effectively highlights dairy-specific contributions to sustainability. In this effort, emotionally engaging communication, such as storytelling around local farmers, traditional practices, or visible animal welfare initiatives, can humanize the sustainability narrative and increase consumer identification with the product. As Mahadeva et al. [74] argue, emotional resonance can be a decisive factor in bridging the intention–action gap.

In parallel, technological innovations are opening new possibilities for improving the credibility and accessibility of sustainability-related information. Tools such as blockchain-based traceability systems or QR codes on packaging allow consumers to access detailed insights into sourcing practices, animal welfare standards, and environmental impact at the farm level [77]. These solutions can enhance transparency and support informed decision-making, but only if the information is presented in a format that is understandable and meaningful to consumers [2]. For example, in a study on consumer preferences for health and organic claims in yogurt, participants perceived organic yogurt to be healthier than yogurt labelled with specific functional health claims, illustrating the dominance of intuitive label interpretation over factual content [78]. This suggests that even well-designed information tools may fail to achieve their objective if not supported by clear contextual explanation. This is particularly relevant in the context of dairy products, where sustainability claims often require contextual interpretation. Research indicates that many consumers struggle to navigate complex or technical information conveyed through labelling, especially when it is presented digitally or outside familiar on-pack formats [2,17,18,76]. Additionally, when compared to plant-based alternatives, traditional dairy products may face a perception gap due to less explicit or less emotionally resonant sustainability narratives, despite comparable or even favorable life-cycle indicators in some cases [7,9].

Moreover, consumer responses to sustainability labelling are shaped not only by sociodemographic characteristics but also by psychological, social, and cultural factors. Younger consumers, particularly Millennials and Generation Z, tend to exhibit stronger preferences for ethical, environmentally responsible brands and are more likely to scrutinize labels and corporate sustainability claims [74]. However, as Turut [10] and Cook et al. [2] point out, a significant gap persists between green attitudes and actual purchasing behavior, partly due to skepticism about the authenticity of sustainability claims and the perceived trade-offs between environmental and functional product benefits. Increased awareness of "greenwashing" and a lack of standardization among labels further contribute to this gap, highlighting the need for more consistent, verifiable, and transparent communication strategies.

Consumers of fermented milk beverages expect certifications to encompass animal-welfare aspects; in a study spanning five European countries, this factor outweighed even environmental concerns as the principal purchase determinant [54]. Experiments with carbon-footprint labels indicate that such tags increase the selection of plant-based products (milks and cheeses) yet have not, so far, led to higher sales of plant-based yogurts [65].

5.3. From Information to Engagement

To build trust and foster loyalty among consumers, dairy producers must go beyond basic compliance and engage in transparent, credible communication strategies. This includes aligning labelling practices with broader sustainability narratives and integrating them into meaningful corporate social-responsibility efforts. Authenticity and emotional resonance, such as through storytelling or third-party endorsements, can be key to bridging the intention–action gap and strengthening brand engagement in an increasingly value-driven market. Examples from industry show that combining third-party certifications with interactive and narrative-driven labelling can improve consumer perception and engagement. Some brands have introduced smart packaging features, allowing consumers to explore a product's origin, environmental footprint, and production conditions through digital tools. These practices illustrate how labelling can transcend its informational function to become an immersive component of the brand–consumer relationship [2].

As modern consumers grow increasingly health-conscious and environmentally aware, the information displayed on product packaging is no longer perceived as merely supplementary, but rather central to purchase intent. Labels are now expected to provide assurance of safety, nutrition, origin, sustainability, and ethical standards. This paper examines the role that digital, environmental, ethical, and origin-based labels play in shaping consumer preferences and behavior when buying dairy milk products [79].

Environmental and ethical labels are powerful tools that signal a product's alignment with sustainable and socially responsible practices. In a study conducted in Japan, researchers assessed the impact of different environmental labels on consumer perception of milk products. The results showed that eco-labels significantly improved customer evaluations of product quality and social value. More importantly, consumers with higher levels of environmental knowledge demonstrated greater sensitivity to green labelling, suggesting that education plays a moderating role in label effectiveness [80].

Similarly, labels such as "organic", "rBST-free", and "animal welfare approved" can influence consumer trust and perceived healthiness of a product. However, these labels may also unintentionally stigmatize conventional milk. Kanter et al. [81] identified this phenomenon in a controlled study, showing that consumers exposed to "organic" and "rBST-free" labels were less likely to choose conventional milk, even when all other factors were equal. This labelling-induced stigma underscores the dual effect of ethical claims, boosting niche product appeal while diminishing perceived value of mainstream alternatives.

Country-of-origin labelling is another key factor in consumer-preference formation. Origin labels can evoke a sense of quality, authenticity, and national pride. Forbes-Brown et al. [82] conducted a discrete choice experiment in Canada and found that consumers were willing to pay a significant premium for milk and ice cream labelled "100% Canadian Milk". The study further noted that consumer knowledge of domestic dairy policies positively influenced their willingness to pay, suggesting that familiarity with local production enhances the value of origin-based labelling. Pedersen et al. [83], analyzing consumer preferences in the United Kingdom, Ireland, and Denmark, showed that information about the origin of milk was rated as an attribute equivalent to organic certification and animal-welfare claims. Local products were rated higher in terms of value, which the authors attributed to shorter supply chains and stronger roots in the national production system, making them more authentic and credible in consumers' eyes. Hay et al. [84], on the other hand, confirmed that geographical origin is a key determinant of the perceived authenticity of yoghurt, with consumer confidence varying depending on the place of production. A study by Chang et al. [85] showed that for consumers in Taiwan, the presence of a health-promoting label was the most important attribute in shaping their preferences for yoghurt, surpassing the importance of characteristics such as the number of probiotic strains, the source of milk,

or technological additives. The results of a study by Wang et al. [86] indicate that Chinese consumers rated grass-fed milk more highly, treating the designation of this origin as a guarantee of naturalness, higher quality, and compliance with expectations for safe and traditional dairy production.

Labelling is a critical driver of consumer purchasing decisions in the dairy industry. Whether through digital access to detailed product data, environmental and ethical certifications, or country-of-origin claims, labels shape consumer perception and purchasing intent. However, the effectiveness of such labelling relies on its clarity, credibility, and regulatory oversight. As consumer expectations evolve, the strategic use of verified and informative labelling will remain essential for dairy producers seeking to build trust and differentiate their products in a competitive market. As dairy producers continue to navigate the shifting landscape of consumer expectations, labelling and certification will remain central elements in shaping how products are perceived and evaluated. Their role, however, cannot be isolated from the broader ecosystem of communication strategies, technological capabilities, and evolving cultural narratives surrounding sustainability [2].

6. Challenges and Limitations of Current Labelling and Certification Systems

One of the primary challenges is the diversity of legal regulations across countries and regions. Across regions, there are similarities in the mandatory information and allergen labelling requirements (Table 1). Across all major regions, several categories of information are universally required on fermented dairy labels. These include the product name, full ingredient list, nutritional composition, allergen declarations, and storage instructions, which together ensure product safety, traceability, and informed consumer choice. Allergen labelling is particularly consistent, with milk recognized globally as a major allergen, and additional emphasis placed on lactose in the European Union or soy in Asian and Latin American markets. While regional frameworks differ in their treatment of organic, origin-based, or specialty claims, this core set of mandatory elements forms the foundation of labelling standards worldwide, providing a baseline for regulatory convergence.

Milk and milk proteins are major allergens and must be clearly highlighted on labels. Fermented milk beverages, however, often contain starter cultures and additional functional ingredients, such as prebiotics or flavoring agents, making it difficult to create a clear and concise label. According to Regulation (EU) No. 1169/2011 [87], allergens must be listed in the ingredients section, but the format and readability of such information often raise concerns [88].

Harmonization efforts, such as those led by the Codex Alimentarius, are helping to align labelling standards internationally, but regional differences remain. Despite the European Union's effort to harmonize food labelling rules through Regulation (EU) No. 1169/2011 [87], national interpretations still differ, especially regarding terms such as "probiotic", "live cultures", or "organic". For instance, the European Food Safety Authority (EFSA) takes a highly restrictive approach to approving health claims, rejecting many claims related to probiotics due to insufficient scientific evidence [89]. This leads to a paradox where the word "probiotic" cannot legally appear on the label, even though its effects have been repeatedly confirmed in scientific studies [90–92]. In contrast, countries like the United States or Japan adopt a more flexible stance on health claims, thus posing challenges for internationally operating companies.

Making nutritional and health claims is a significant challenge for producers of fermented milk beverages. All such claims must be based on scientifically verified evidence and included in the EU Register of Health Claims [89]. Terms like CFU (colony-forming

units) are essential for confirming the presence of probiotics but are difficult for the average consumer to understand [93].

Table 1. Comparison of labelling requirements across regions.

Region	Mandatory Information	Allergen Labelling Requirements	Additional Requirements
United States	Product name, ingredients, nutritional information, allergens, storage instructions	Declaration of major 8 (Big 8) * allergens, including milk	Labels for organic dairy products must comply with USDA organic standards, while terms like "grass-fed" and "non-GMO" are subject to specific definitions
European Union	Product name, ingredients, allergens, nutritional information, storage instructions (EU) No. 1169/2011	Declaration of major allergens, including milk and lactose	Protected designations of origin, geographical indications, and traditional specialty guarantees
China	Product name, ingredients, nutritional information, allergens, storage instructions	Declaration of major allergens, including milk and soy	Organic and specialty product standards
Latin America	Product name, ingredients, nutritional information, allergens, storage instructions	Declaration of major allergens, including milk and soy	Labels for organic and specialty dairy products must comply with national standards, which are increasingly aligned with international practices
South Asian Association for Regional Cooperation (SAARC) Countries	Product name, ingredients, nutritional information, allergens, storage instructions	Declaration of major allergens, including milk and soy	Labels for organic and specialty dairy products must comply with national standards, which are increasingly aligned with international practices

* "The Big 8" refers to eight major food allergens: eggs, milk, tree nuts, peanuts, fish, soy, wheat (gluten), and crustaceans (shellfish). Source: based on [94–96].

Dairy products are not without examples of greenwashing practices. In 2025, Greenpeace Denmark lodged an official complaint with the Danish Business Authority (the regulatory institution overseeing corporate conduct in Arla's country of origin) accompanied by extensive evidence suggesting that the dairy corporation has substantially exaggerated its reported reductions in CO_2 emissions. Arla asserts that it has achieved a 13% decrease in greenhouse gas emissions across its supply chain since 2015. However, the complaint contends that nearly half of this reduction was abruptly recorded in 2016, coinciding with a shift in the company's calculation methodology, which was implemented without a corresponding adjustment to the baseline year. Greenpeace Denmark maintains that this alteration not only presents a misleading narrative to consumers but may also constitute a violation of financial reporting regulations in both Denmark and Sweden [97].

7. Emerging Technologies Supporting Transparency and Verification in Labelling

As the demand for transparency in dairy labelling grows, the integration of digital solutions like QR codes and blockchain technology not only enhances traceability

but also empowers consumers to engage with the sustainability narrative of their food choices (Table 2).

Table 2. Digital technologies supporting transparency and traceability in dairy labelling.

Technology	Key Features	Citation
RFID	Real-time monitoring, inventory management, and traceability	[98,99]
QR Codes	Consumer engagement, traceability, and marketing opportunities	[100]
Blockchain	Decentralized, tamper-proof, smart contracts, and quality control	[101]
Green blockchain	Environmentally friendly, low energy consumption, and cost savings	[98]
Internet of Things (IoT)	IoT devices monitor conditions such as temperature and CO_2 levels, enhancing biosecurity and product quality IoT combined with blockchain provides end-to-end tracking and monitoring, ensuring transparency and traceability in supply chains	[101]
Digital passports/carbon footprint	Detailed product information, real-time data sharing, and consumer trust	[96]

QR codes are often printed on milk bottles, cheese packages, and other dairy products. These codes can be scanned using smartphones, allowing consumers to access information about the product's origin, nutritional content, and production process [99,100]. By scanning a QR code, consumers can access detailed information about the product's journey, including its environmental impact and ethical considerations, thus bridging the gap between consumer expectations and the realities of production methods. Research suggests that such solutions are well-accepted by consumers and may influence purchasing decisions; for instance, in a retail experiment, 48% of QR code scans led to a milk purchase [102]. Moreover, the use of QR codes has been shown to improve consumer comprehension and confidence regarding product attributes, reducing the frequency of "don't know" responses and increasing the accuracy of answers [103]. This shift toward digital transparency aligns with emerging consumer trends that prioritize informed decision-making, as studies indicate that consumers increasingly seek reliable information to guide their purchasing behaviors [27].

Blockchain provides end-to-end traceability, allowing consumers to track the origin of their dairy products and ensuring that products meet quality and safety standards [104]. Blockchain can be integrated with IoT sensors to monitor the quality of milk during production and transportation. For example, sensors can track temperature, pH levels, and other parameters to ensure that products remain fresh and safe for consumption [94]. Sustainability benefits cannot be overlooked when speaking about technology. Firstly, waste reduction can be achieved. By improving supply chain efficiency, blockchain and IoT technologies can help reduce waste in the dairy industry. Research conducted by Fonseca and Garracho [105] shows that real-time monitoring of milk quality can prevent spoilage during transportation. Secondly, green blockchain and other sustainable technologies are being developed to reduce the energy consumption associated with blockchain operations. This makes blockchain a more environmentally friendly option for traceability in the dairy industry [106]. And thirdly, the use of eco-friendly materials in packaging, combined with blockchain technology, can enhance the sustainability of dairy products. As reported by Hassoun et al. [107], biodegradable packaging materials can be tracked using blockchain to ensure they are disposed of properly. However, the challenge remains that while these technologies promise increased access to information, they must also be coupled with effective educational initiatives to ensure that consumers can interpret this data meaningfully, thus fostering a more robust understanding of sustainability in dairy products.

As the dairy industry can increasingly embrace technological innovations, the potential for enhancing consumer engagement through personalized marketing strategies emerges as one of the ways for driving sustainable practices. By utilizing data analytics and

consumer feedback, producers can tailor their communication efforts to resonate with specific demographics, particularly younger consumers who prioritize sustainability in their purchasing decisions. This approach not only fosters a deeper connection between brands and consumers but also encourages a shared commitment to sustainability, as consumers feel more invested in the practices of the brands they support. Furthermore, the rise of social media platforms offers a unique opportunity for dairy producers to showcase their sustainability initiatives in real time, effectively bridging the gap between consumer expectations and industry practices [106]. Such dynamic interactions can demystify the complexities of dairy production, ultimately cultivating a more informed and responsible consumer base that actively seeks out genuinely sustainable products.

Digital innovation is actively strengthening these regulatory networks. Blockchain pilots, endorsed by Codex working groups, demonstrate that immutable ledgers can store herd data, audit certificates, and cold-chain metrics, enabling inspectors and consumers to verify batch-specific compliance via QR code scans [55]. Such integration of public oversight with distributed technologies addresses trade-off between credibility, accessibility, and continuous improvement identified for private dairy standards, offering a pathway to more transparent and accountable certification regimes [53].

Innovations in certification increasingly rely on digital infrastructures that pair end-to-end traceability with consumer-facing transparency. A bibliometric review of 61 peer-reviewed papers identifies blockchain as the most promising architecture for food supply-chain assurance, emphasizing immutability, tamper-resistance, and real-time data sharing as primary advantages for curbing label fraud [108]. Case-study modelling indicates that integrating blockchain with just-in-time logistics and sensor streams can reduce verification time for individual milk batches and lower warehouse losses, although adoption is currently hindered by upfront costs and the absence of harmonized regulatory guidance [109]. Pilot work in a U.S. dairy co-operative confirms these efficiencies, reporting faster exception handling and automated compliance reports once transaction records are synchronized across processors and farms [110].

Interactive labelling technologies translate backend traceability into shopper-level engagement. Field tests with QR-enabled "dynamic shelf-life" labels on milk demonstrated that over 60% of scanned packs were subsequently purchased, and half of all scans converted to sales, indicating that digitally enriched information can boost both trust and uptake [102]. When blockchain ledgers are linked to QR codes, additional quality attributes, such as temperature history, feed origin, and audit certificates, can be presented to consumers without overloading on-pack real estate; such hybrid systems have been shown to raise overall Food Quality 4.0 scores in traceability assessments [111]. A Greek yogurt study further reports that "scan-to-learn" labels increase perceived brand transparency and willingness to pay, provided the data are presented in an intuitive dashboard [103].

Digital innovation must also address socio-economic disparities in label comprehension. Behavioral experiments with Swedish shoppers reveal that low-income households prioritize price and experience cognitive overload when confronted with complex eco-icons; simplified mobile explanations and in-store prompts are recommended to bridge this "information capability gap" [112]. Complementary sensory research indicates that climate-footprint and animal-welfare cues can generate a healthfulness halo unless accompanied by numerical context, underscoring the need for data-rich yet accessible presentation formats [7]. Proposed "Quality 4.0" frameworks therefore advocate for the integration of public certification databases with distributed ledgers and visual traffic-light indicators, balancing audit-grade detail with rapid consumer interpretation [55]. Collectively, these studies suggest that coupling blockchain traceability with interactive, user-friendly labelling, and supporting both with targeted education, can strengthen certifi-

cation integrity while ensuring that transparency benefits are equitably distributed across consumer segments.

The credibility of certification for fermented dairy products fundamentally rests on three pillars: clear, measurable environmental indicators; unequivocal guarantees of animal welfare; and a simple ingredient list verified through rigorous laboratory testing. Without this triad, even the most sophisticated labels (organic, Eco-Score, or carbon footprint) risk creating a halo effect that misguides consumers. Routine genomic and chemometric checks, combined with blockchain-based ledgers and interactive QR codes, ensure that each milk batch is traceable and audit-ready, while public databases and annual inspections anchor the system's integrity despite ongoing administrative burdens.

8. Future Directions, Limitations, and Recommendations

Ensuring the authenticity and effectiveness of sustainability claims in the fermented dairy sector requires a future-oriented, systemic approach that addresses the interplay between regulatory frameworks, technological infrastructure, consumer perception, and market realities. A fundamental direction involves the harmonization of certification criteria and legal definitions at international and regional levels. The current fragmentation, where terms such as "probiotic", "organic", or "carbon-neutral" are interpreted differently depending on jurisdiction, not only hampers standardization but also undermines the credibility of labels. Establishing unified, scientifically grounded benchmarks across global markets would enhance transparency and facilitate the comparability of claims, particularly for transnational producers.

Moreover, it is essential to integrate advanced digital technologies, such as blockchain-enabled traceability, interactive QR codes, and digital product passports, into mainstream certification schemes. These tools have the potential to validate claims at the batch level; support real-time auditing; and deliver tamper-proof data on environmental metrics, animal welfare, and cold-chain integrity. However, their adoption must be accompanied by targeted public investment and policy support, particularly for small-scale producers who may lack the resources to implement high-tech systems. Without such support, the technological divide risks exacerbating inequalities in market access and weakening the inclusiveness of sustainable transformation.

Another critical future direction lies in the simplification and standardization of label design. Current labelling systems often overload consumers with information or use ambiguous visual cues, leading to confusion and the halo effect, where a single term such as "organic" unjustifiably shapes perception across unrelated attributes. Labels should be designed using clear, intuitive, and harmonized iconography, prioritizing accessibility for diverse consumer groups. Visual elements must align with textual content and legal claims to avoid cognitive dissonance or misinterpretation.

To complement technological and visual improvements, consumer education initiatives must be significantly strengthened. As shown in recent studies, sustainability comprehension remains low, and the intention–action gap persists due to limited understanding of indicators such as carbon footprint or probiotic functionality. Educational strategies should be co-developed with civil society, schools, and media platforms, focusing on translating scientific concepts into relatable, actionable knowledge. Digital labels must not only present data but contextualize them meaningfully, ensuring that consumers are not merely informed but empowered.

Furthermore, the credibility of certification schemes should rest on empirical verification. Advances in metagenomics, rapid DNA assays, and chemical analysis offer unprecedented opportunities to validate claims concerning microbial composition, allergen presence, and nutritional accuracy. These tools must be embedded as standard practice

in certification audits, thereby closing the gap between declared attributes and product reality. Without such safeguards, the risk of greenwashing remains acute, as evidenced by high-profile cases of label manipulation and regulatory complaints.

Finally, the sustainability discourse must adopt a more participatory and emotionally engaging dimension. Narratives that highlight local farmers, traditional production practices, and community impact can humanize sustainability claims and resonate more deeply with ethically motivated consumers. Combining third-party certifications with storytelling strategies and real-time consumer engagement, especially via mobile platforms and social media, may reinforce trust and foster long-term loyalty. The effectiveness of sustainability communication hinges not only on factual precision, but also on its emotional authenticity and cultural relevance.

Despite these opportunities, several limitations must be acknowledged. First, the existing body of research on certification and labelling in fermented dairy products remains uneven across regions, with most studies concentrated in Europe and North America. This imbalance constrains the generalizability of findings to other cultural and regulatory contexts. Second, much of the available evidence is fragmented, focusing on individual aspects such as consumer perception, regulatory design, or technological solutions, rather than their interdependence. Third, the pace of technological and regulatory change outstrips academic analysis, which risks rendering some insights quickly outdated. Finally, narrative reviews such as this one, while valuable for synthesis, cannot claim the exhaustive coverage of systematic reviews. These limitations underscore the need for ongoing, comparative, and interdisciplinary research to refine and test the recommendations proposed above.

Consequently, the path forward must combine regulatory harmonization, technological integration, simplified communication, empirical verification, and inclusive storytelling. Only by aligning these dimensions can the fermented dairy sector realise its potential as a driver of genuine, system-wide sustainability.

9. Conclusions

Certifications and labels play a crucial role in building credibility and advancing the sustainability agenda in the fermented dairy sector. In the context of globalized supply chains and rising consumer expectations, these tools function not only as verification mechanisms but also as key channels of communication between producers and consumers. However, the current landscape remains fragmented: inconsistent definitions, overlapping schemes, and unclear messaging undermine trust and reduce the transformative potential of sustainability claims.

This review shows that the perceived value of certification depends on three critical factors: trust in the certifying institution, clarity of the label format, and the extent to which claims are reflected in tangible product characteristics. Certifications issued by independent, public, or internationally recognized bodies consistently outperform producer-originated labels regarding perceived authenticity.

At the same time, the way sustainability is communicated matters deeply. Narratives centered on local farmers, animal welfare, or biodiversity protection can foster a stronger emotional connection than abstract terminology. When scientifically grounded and emotionally resonant, labels are more likely to motivate behavioral change.

Technological innovations, such as blockchain traceability and digital product passports, offer promising tools for strengthening transparency and interactivity. However, their implementation must remain inclusive, particularly for small producers. Similarly, standardized laboratory-based verification (e.g., DNA, metagenomics and nutrient profiling) is needed to substantiate claims and protect against greenwashing.

Ultimately, the future of sustainable dairy labelling lies in integrated solutions: scientifically robust, visually intuitive, and culturally responsive. Labels must evolve from static declarations into trust-building interfaces; tools that inform, engage, and reflect the diversity of consumer needs. This evolution is not optional; it is imperative.

Author Contributions: Conceptualization, M.K. (Małgorzata Krzywonos); formal analysis, M.A., M.K. (Małgorzata Krzywonos), M.H., A.P., S.S., P.Ż., S.P., B.P., B.J., and M.K. (Michał Kucia); investigation, M.A., M.K. (Małgorzata Krzywonos), M.H., A.P., S.S., P.Ż., S.P., B.P., B.J., and M.K. (Michał Kucia); data curation, M.A., M.K. (Małgorzata Krzywonos), M.H., A.P., S.S., P.Ż., S.P., B.P., B.J., and M.K. (Michał Kucia); writing—original draft preparation, M.A., M.K. (Małgorzata Krzywonos), M.H., A.P., S.S., P.Ż., and S.P.; writing—review and editing, M.A., M.K. (Małgorzata Krzywonos), and M.H.; supervision, M.K. (Małgorzata Krzywonos); project administration, M.A.; funding acquisition, M.A., M.H., and P.Ż., B.J. All authors have read and agreed to the published version of the manuscript.

Funding: This work was realized as part of the Inter-University Research Grant SGH-UEW-UEK-UEP-UEKat entitled "Communication value of sustainable products and consumer behaviour".

Acknowledgments: During the preparation of this work, the authors used Chat GPT and Grammarly to check the grammar and rewrite some sentences. After using this tool, the authors reviewed and edited the content as needed, and take they full responsibility for the content of the publication.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Miller, K.B.; Eckberg, J.O.; Decker, E.A.; Marinangeli, C.P.F. Role of Food Industry in Promoting Healthy and Sustainable Diets. *Nutrients* **2021**, *13*, 2740. [CrossRef]
2. Cook, B.; Costa Leite, J.; Rayner, M.; Stoffel, S.; van Rijn, E.; Wollgast, J. Consumer interaction with sustainability labelling on food products. *Nutrients* **2023**, *15*, 3837. [CrossRef]
3. Dewick, P.; Foster, C.; Green, K. Technological Change and the Environmental Impacts of Food Production and Consumption: The Case of the UK Yogurt Industry. *J. Ind. Ecol.* **2008**, *11*, 133–146. [CrossRef]
4. Košičiarová, I.; Nagyová, L.; Holienčinová, M. Consumer Behaviour on Slovak Yoghurt and Fermented Milk Products Market. *Acta Univ. Agric. Silvic. Mendel. Brun.* **2017**, *65*, 1967–1978. [CrossRef]
5. Riar, H.; Goel, N. Advancements in functionality and quality characteristic of yoghurt—A fermented dairy product: A review. *Environ. Conserv. J.* **2021**, *22*, 49–54. [CrossRef]
6. Wojnarowska, M.; Sołtysik, M.; Prusak, A. Impact of eco-labelling on the implementation of sustainable production and consumption. *Environ. Impact Assess. Rev.* **2021**, *86*, 106505. [CrossRef]
7. Schiano, A.N.; Harwood, W.S.; Gerard, P.D.; Drake, M. Consumer perception of the sustainability of dairy products and plant-based dairy alternatives. *J. Dairy Sci.* **2020**, *103*, 11228–11243. [CrossRef]
8. Bintsis, T.; Papademas, P. The Evolution of Fermented Milks, from Artisanal to Industrial Products: A Critical Review. *Fermentation* **2022**, *8*, 679. [CrossRef]
9. Naspetti, S.; Mandolesi, S.; Buysse, J.; Latvala, T.; Nicholas, P.; Padel, S.; Van Loo, E.J.; Zanoli, R. Consumer perception of sustainable practices in dairy production. *Agric. Econ.* **2021**, *9*, 1. [CrossRef]
10. Turut, O. The power of silent sustainability: Communication strategies for new sustainable products. *Clean. Responsible Consum.* **2024**, *14*, 100220. [CrossRef]
11. Teufer, B.; Waiguny, M.K.J.; Grabner-Kreuter, S. Consumer perceptions of sustainability labels for alternative food networks. *Baltic J. Manag.* **2023**, *18*, 493–508. [CrossRef]
12. Jürkenbeck, K. The effect of information among established and new sustainability labelling on consumers' preference and willingness to pay. *Clean. Responsible Consum.* **2023**, *10*, 100131. [CrossRef]
13. Arayess, S.; de Boer, A. How to Navigate the Tricky Landscape of Sustainability Claims in the Food Sector. *Eur. J. Risk Regul.* **2022**, *13*, 643–664. [CrossRef]
14. Tiekstra, S.; Dopico-Parada, A.; Koivula, H.; Lahti, J.; Buntinx, M. Holistic Approach to a Successful Market Implementation of Active and Intelligent Food Packaging. *Foods* **2021**, *10*, 465. [CrossRef]
15. Garg, V.; Velumani, D.; Lin, Y.C.; Haye, A. A comprehensive review of probiotic claim regulations: Updates from the Asia-Pacific regions, the United States, and Europe. *PharmaNutrition* **2024**, *30*, 100423. [CrossRef]
16. Do, T.T.; Le, M.T. Unveiling the halo effect: Exploring the influence of organic labels on consumer behavior in the organic cosmetics market. *Curr. Psychol.* **2025**, *44*, 9803–9824. [CrossRef]

17. Neuhofer, Z.T.; Lusk, J.L.; Villas-Boas, S.B. Can a sustainability facts label reduce the halo surrounding organic labels? *Appl. Econ. Perspect. Policy* **2023**, *45*, 2204–2234. [CrossRef]
18. Ruiz, F.; Santa, G.M.; Cárdenas, M.V.; Morales, J.A.R. Organic Food Labeling and Consumer Perception: Empirical Evidence. *Ciencia Ergo Sum* **2024**, *32*.
19. Heerwagen, L.R.; Mørkbak, M.R.; Denver, S.; Sandøe, P.; Christensen, T. The role of quality labels in market-driven animal welfare. *J. Agric. Environ. Ethics* **2015**, *28*, 67–84. [CrossRef]
20. Dahlhausen, J.L.; Rungie, C.; Roosen, J. Value of labeling credence attributes—Common structures and individual preferences. *Agric. Econ.* **2018**, *49*, 741–751. [CrossRef]
21. Piracci, G.; Lamonaca, E.; Santeramo, F.G.; Boncinelli, F.; Casini, L. On the willingness to pay for food sustainability labelling: A meta-analysis. *Agric. Econ.* **2024**, *55*, 329–345. [CrossRef]
22. Tonkin, E.; Meyer, S.B.; Coveney, J.; Webb, T.; Wilson, A.M. The process of making trust-related judgements through interaction with food labelling. *Food Policy* **2016**, *63*, 1–11. [CrossRef]
23. Banerjee, R.; Quinn, B. Exploring consumer constructions of local food: Meanings and influences. *Eur. J. Mark.* **2022**, *56*, 1269–1300. [CrossRef]
24. Tamime, A.Y.; Hickey, M.; Muir, D.D. Strained fermented milks—A review of existing legislative provisions, survey of nutritional labelling of commercial products in selected markets and terminology of products in some selected countries. *Int. J. Dairy Technol.* **2014**, *67*, 305–333. [CrossRef]
25. Passos, A.A.C.; Silva, A.J.L.; Lopes, S.A.; Braga, R.C.; Cavalcante, A.B.D.; Pereira, J.O.P. Physicochemical characterization and label comparison among diet yogurts sold in the city of Limoeiro do Norte–CE. *Food Sci. Technol.* **2016**, *37*, 131–134. [CrossRef]
26. van der Zee, E. Regulatory Structure Underlying Sustainability Labels. In *Sustainability Labels in the Shadow of the Law*; Studies in European Economic Law and Regulation; Springer: Cham, Switzerland, 2022; Volume 22, pp. 17–31.
27. Heim, H. Label Conscious: Communicating Verifiable Sustainable Impact by Labelling Garments with Smart Technology. In *Fashion Communication*; FACTUM 2021; Sádaba, T., Kalbaska, N., Cominelli, F., Cantoni, L., Torregrosa Puig, M., Eds.; Springer: Cham, Switzerland, 2021; pp. 173–186. [CrossRef]
28. Srivastav, A.K.; Das, P. Challenges and Barriers to Adoption. In *Biotechnology and IoT in Agriculture and Food Production*; Apress: Berkeley, CA, USA, 2025.
29. Vermeir, I.; Roose, G. Visual design cues impacting food choice: A review and future research agenda. *Foods* **2020**, *9*, 1495. [CrossRef]
30. Corallo, A.; Latino, M.E.; Menegoli, M.; Pizzi, R. Assuring effectiveness in consumer-oriented traceability; Suggestions for food label design. *Agronomy* **2021**, *11*, 613. [CrossRef]
31. Wu, W.; Zhang, A.; van Klinken, R.D.; Schrobback, P.; Muller, J.M. Consumer trust in food and the food system: A critical review. *Foods* **2021**, *10*, 2490. [CrossRef] [PubMed]
32. Sylvester, A.; Tate, M.; Johnstone, D. Beyond synthesis: Re-presenting heterogeneous research literature. *Behav. Inf. Technol.* **2013**, *32*, 1199–1215. [CrossRef]
33. Templier, M.; Paré, G. A framework for guiding and evaluating literature reviews. *Commun. Assoc. Inf. Syst.* **2015**, *37*, 112–137. [CrossRef]
34. Turnbull, D.; Chugh, R.; Luck, J. Systematic-narrative hybrid literature review: A strategy for integrating a concise methodology into a manuscript. *Soc. Sci. Humanit. Open* **2023**, *7*, 100381. [CrossRef]
35. Snyder, H. Literature review as a research methodology: An overview and guidelines. *J. Bus. Res.* **2019**, *104*, 333–339. [CrossRef]
36. Mengistu, A.; Dieste, M.; Panizzolo, R.; Biazzo, S. Sustainable product design factors: A comprehensive analysis. *J. Clean. Prod.* **2024**, *463*, 142260. [CrossRef]
37. Romulo, A.; Surya, R. Tempe: A traditional fermented food of Indonesia and its health benefits. *Int. J. Gastronomy Food Sci.* **2021**, *26*, 100413. [CrossRef]
38. Ogrodowczyk, A.M.; Modzelewska-Kapituła, M. Recent advances in fermented milk and meat products—Quality, nutritional value and safety. *Animals* **2023**, *13*, 2048. [CrossRef]
39. Ganatsios, V.; Nigam, P.; Plessas, S.; Terpou, A. Kefir as a Functional Beverage Gaining Momentum towards Its Health Promoting Attributes. *Beverages* **2021**, *7*, 48. [CrossRef]
40. Feil, A.A.; Schreiber, D.; Haetinger, C.; Haberkamp, Â.M.; Kist, J.I.; Rempel, C.; Maehler, A.E.; Gomes, M.C.; da Silva, G.R. Sustainability in the dairy industry: A systematic literature review. *Environ. Sci. Pollut. Res.* **2020**, *27*, 33527–33542. [CrossRef] [PubMed]
41. Tricarico, J.; Kebreab, E.; Wattiaux, M. MILK Symposium review: Sustainability of dairy production and consumption in low-income countries with emphasis on productivity and environmental impact. *J. Dairy Sci.* **2020**, *103*, 9791–9802. [CrossRef]
42. Knight, C. Achieving sustainable production of milk. *J. Dairy Res.* **2017**, *84*, 370–371. [CrossRef]
43. Wouters, J.; Ayad, E.; Hugenholtz, J.; Smit, G. Microbes from raw milk for fermented dairy products. *Int. Dairy J.* **2002**, *12*, 91–109. [CrossRef]

44. Bojovic, M.; McGregor, A. To milk, or not to milk? Exploring just and sustainable transition pathways for Aotearoa New Zealand's dairy sector. *J. Rural Stud.* **2025**, *114*, 103540. [CrossRef]
45. Rees, W.; Tremma, O.; Manning, L. Sustainability cues on packaging: The influence of recognition on purchasing behavior. *J. Clean. Prod.* **2019**, *235*, 841–853. [CrossRef]
46. Otto, S.; Strenger, M.; Maier-Nöth, A.; Schmid, M. Food packaging and sustainability—Consumer perception vs. correlated scientific facts: A review. *J. Clean. Prod.* **2021**, *298*, 126733. [CrossRef]
47. Norton, V.; Oloyede, O.; Lignou, S.; Wang, Q.J.; Vásquez, G.; Alexi, N. Understanding consumers' sustainability knowledge and behaviour towards food packaging. *J. Clean. Prod.* **2023**, *408*, 137169. [CrossRef]
48. Santos, V.; Gomes, S.; Nogueira, M. Sustainable packaging: Does eating organic really make a difference on product-packaging interaction? *J. Clean. Prod.* **2021**, *304*, 127066. [CrossRef]
49. Martinho, G.; Pires, A.; Portela, G.; Fonseca, M. Factors affecting consumers' choices concerning sustainable packaging during product purchase and recycling. *Resour. Conserv. Recycl.* **2015**, *103*, 58–68. [CrossRef]
50. Futtrup, R.; Tsalis, G.; Pedersen, S.; Dean, M.; Benson, T.; Aschemann-Witzel, J. Is the whole more than the sum of its parts? *Sustain. Prod. Consum.* **2021**, *28*, 1411–1421. [CrossRef]
51. Ampuero Canellas, O.; González Del Río, J.; Tarazona Belenguer, N. Communicating sustainability through packaging graphic design: Associated sociodemographic factors. *Design Principles Pract.* **2023**, *17*, 1–21. [CrossRef]
52. Kühl, S.; Gassler, B.; Spiller, A. Labeling strategies to overcome the problem of niche markets for sustainable milk products. *J. Dairy Sci.* **2017**, *100*, 5082–5096. [CrossRef]
53. McGarr-O'Brien, K.; Herron, J.; Shalloo, L.; De Boer, I.J.M.; De Olde, E.M. Characterising sustainability certification standards in dairy production. *Animal* **2023**, *17*, 100863. [CrossRef] [PubMed]
54. Ammann, J.; Mack, G.; El Benni, N.; Jin, S.; Newell-Price, P.; Tindale, S.; Hunter, E.; Vicario-Modroño, V.; Gallardo-Cobos, R.; Sánchez-Zamora, P. Consumers across five European countries prioritise animal welfare above environmental sustainability when buying meat and dairy products. *Food Qual. Prefer.* **2024**, *117*, 105179. [CrossRef]
55. Khanna, A.; Jain, S.; Burgio, A.; Bolshev, V.; Panchenko, V. Blockchain-enabled supply chain platform for Indian dairy industry: Safety and traceability. *Foods* **2022**, *11*, 2716. [CrossRef]
56. Gillespie, J.; Raszap Skorbiansky, S.; Law, J. Certified Organic Dairy Production: Three Decades of Growth. USDA Economic Research Service, Economic Research Report No. 335. 2024. Available online: https://ers.usda.gov/sites/default/files/_laserfiche/publications/109948/ERR-335.pdf?v=44059 (accessed on 1 August 2025).
57. Carrión-Bósquez, N.; Veas-González, I.; Naranjo-Armijo, F.; Llamo-Burga, M.; Ortiz-Regalado, O.; Ruiz-García, W.; Guerra-Regalado, W.; Vidal-Silva, C. Advertising and eco-labels as influencers of eco-consumer attitudes and awareness—Case study of Ecuador. *Foods* **2024**, *13*, 228. [CrossRef]
58. Osman, A.D.; Bahaciu, G.V.; Marin, M.; Defta, N.; Enea, D.; Stanciu, M.A.; Vidu, L. Dynamics of certification of traditional dairy products at EU level and specifically for Romania. *Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural Dev.* **2024**, *67*, 538–547.
59. Sorley, M.; Casey, I.; Styles, D.; Merino, P.; Trindade, H.; Mulholland, M.; Resch Zafra, C.; Keatinge, R.; Le Gall, A.; O'Brien, D. Factors influencing the carbon footprint of milk production on dairy farms with different feeding strategies in Western Europe. *J. Clean. Prod.* **2024**, *435*, 140104. [CrossRef]
60. Syahlani, S.P.; Triatmojo, A.; Dewi, N.M.A.K. The influence of certification on perceived product quality of livestock food products. *IOP Conf. Ser. Earth Environ. Sci.* **2024**, *1292*, 012026. [CrossRef]
61. Vashisht, P.; Singh, L.; Saini, G.S.; Gill, A.; Verma, D.; Sharma, A.; Bihola, A.; Sahni, O.; Kaur, J.; Chauhan, D.S. Review of potential clean label ingredients in yogurt, cheese and ice cream sector. *Food Humanit.* **2025**, *4*, 100474. [CrossRef]
62. Ferronato, G.; Tobanelli, N.; Bani, P.; Cattaneo, L. Carbon footprint assessment of dairy milk and Grana Padano PDO cheese and improvement scenarios: A case study in the Po Valley (Italy). *Animals* **2025**, *15*, 811. [CrossRef] [PubMed]
63. Canavari, M.; Coderoni, S. Consumer stated preferences for dairy products with carbon footprint labels in Italy. *Agric. Food Econ.* **2020**, *8*, 4. [CrossRef]
64. Burstow, A.; Witt, B.G.; Thompson, C. Food shopping is not a leisure activity: Consumer heuristics and their impact on the effectiveness of ecolabels on Australian dairy products. *Food Humanit.* **2025**, *4*, 100531. [CrossRef]
65. Katare, B.; Zhao, S. Behavioral interventions to motivate plant-based food selection in an online shopping environment. *Proc. Natl. Acad. Sci. USA* **2024**, *121*, e2319018121. [CrossRef]
66. Mottola, A.; Piredda, R.; Lorusso, L.; Ranieri, L.; Di Pinto, A. Species substitution in goat yoghurt supply chain using melting-curve analysis. *J. Food Compos. Anal.* **2024**, *126*, 105866. [CrossRef]
67. Chornchoem, P.; Tandhavanant, S.; Saiprom, N.; Preechanukul, A.; Thongchompoo, N.; Sensorn, I.; Chantratita, W.; Chantratita, N. Metagenomic evaluation, antimicrobial activities, and immune stimulation of probiotics from dietary supplements and dairy products. *Sci. Rep.* **2025**, *15*, 11537. [CrossRef]

68. O'Mahony, S.; O'Donovan, C.B.; McDonald, K.; Lyons, O.C.; Quinn, S.F.; Creane, R.J.; Flynn, M.A.T.; Anderson, W.; Gibney, E.R.; Collins, N.A. The accuracy of nutrition labels as a means of monitoring the reformulation of food in Ireland—The case of yoghurts. *Proc. Nutr. Soc.* **2020**, *79*, E713. [CrossRef]
69. Sharib, J.R.; Pomeranz, J.L.; Mozaffarian, D.; Cash, S.B. Disclosure of mandatory and voluntary nutrition labelling information across major online food retailers in the USA. *Public Health Nutr.* **2024**, *27*, e203. [CrossRef] [PubMed]
70. Metras, B.N.; Holle, M.J.; Parker, V.J.; Miller, M.J.; Swanson, K.S. Commercial kefir products assessed for label accuracy of microbial composition and density. *JDS Commun.* **2021**, *2*, 87–91. [CrossRef]
71. James, C.A.; Welham, S.; Rose, P. Evaluation of food allergen information, labelling and unintended food allergen presence in imported prepacked foods and drinks purchased online in the UK. *Food Control* **2024**, *162*, 110462. [CrossRef]
72. Jin, S.; Matsuoka, Y.; Yue, M.; Jones, G.; Frewer, L.J. Does information about environmental considerations affect Chinese and UK consumers' purchase intentions for traced foods? A path analysis. *Environ. Dev. Sustain.* **2024**, *26*, 32287–32318. [CrossRef]
73. Büttner, V.; Gassler, B.; Teuber, R. Does the Eco-Score lead to a halo effect? Influence of a sustainability label on product perceptions and purchase intention. *Food Qual. Prefer.* **2024**, *121*, 105246. [CrossRef]
74. Mahadeva, R.; Ganji, E.N.; Shah, S.R. Sustainable consumer behaviours through comparisons of developed and developing nations. *Int. J. Environ. Eng. Dev.* **2024**, *2*, 106–125. [CrossRef]
75. Brkić, I.; Puvača, N. Economic and Ecological Sustainability of Dairy Production. *J. Agron. Technol. Eng. Manag.* **2024**, *7*, 1088–1104. [CrossRef]
76. Schiano, A.N.; Drake, M. Invited review: Sustainability: Different perspectives, inherent conflict. *J. Dairy Sci.* **2021**, *104*, 11386–11400. [CrossRef] [PubMed]
77. Tolegenov, B.; Rafif, K.; Rafi, M.; Herawati, R.; Abdullah, A.; Sari, L.T. Digital transparency and consumer awareness: Digital platforms for educating consumers about product origins and sustainability. *J. Al-Muzaraah'ah* **2024**, *12*, 277–287. [CrossRef]
78. Gineikiene, J.; Kiudyte, J.; Degutis, M. Functional, organic or conventional? Food choices of health conscious and skeptical consumers. *Baltic J. Manag.* **2017**, *12*, 139–152. [CrossRef]
79. Marchini, A.; Riganelli, C.; Diotallevi, F.; Polenzani, B. Label Information and Consumer Behaviour: Evidence on Drinking Milk Sector. *Agric. Food Econ.* **2021**, *9*, 8. [CrossRef]
80. Tansakul, N.; Suanmali, S.; Shirahada, K. The impact of product labels on green preferences and perceptions of customers: An empirical study of milk products in Japan. *Int. J. Sustain. Soc.* **2018**, *10*, 75–91. [CrossRef]
81. Kanter, C.A.; Messer, K.D.; Kaiser, H.M. Does production labeling stigmatize conventional milk? *Am. J. Agric. Econ.* **2009**, *91*, 1097–1109. [CrossRef]
82. Forbes-Brown, S.; Micheels, E.; Hobbs, J. Consumer willingness to pay for dairy products with the 100% Canadian Milk label: A discrete choice experiment. *J. Int. Food Agribus. Mark.* **2016**, *28*, 203–224. [CrossRef]
83. Pedersen, S.; Benson, T.; Tsalis, G.; Futtrup, R.; Dean, M.; Aschemann-Witzel, J. What consumers want in a sustaina-bility food label: Results from online co-creation workshops in the United Kingdom, Ireland and Denmark. *Front. Sustain.* **2024**, *4*, 1342215. [CrossRef]
84. Hay, C.; De Matos, A.D.; Low, J.; Feng, J.; Lu, D.; Day, L.; Hort, J. Comparing cross-cultural differences in perception of drinkable yoghurt by Chinese and New Zealand European consumers. *Int. Dairy J.* **2021**, *113*, 104901. [CrossRef]
85. Chang, M.Y.; Huang, C.C.; Du, Y.C.; Chen, H.S. Choice Experiment Assessment of Consumer Preferences for Yogurt Products Attributes: Evidence from Taiwan. *Nutrients* **2022**, *14*, 3523. [CrossRef] [PubMed]
86. Wang, J.; Li, C.; Dong, X.; Gao, Z.; Gibney, E.R.; Yang, S.; McGuinness, L.; Noronha, N.; Feeney, E.L. Food labeling Chinese consumer preference for naturalness: Anew way to differentiate grass-fed dairy products. *J. Dairy Sci.* **2025**, *108*, 2340–2353. [CrossRef]
87. European Parliament and Council of the European Union. Regulation (EU) No 1169/2011 on the Provision of Food Information to Consumers. *Off. J. Eur. Union* **2011**, *L304*, 18–63. Available online: https://eur-lex.europa.eu/eli/reg/2011/1169/oj (accessed on 1 August 2025).
88. Chang, F.; Eng, L.; Chang, C. Food Allergy Labeling Laws: International Guidelines for Residents and Travelers. *Clin. Rev. Allergy Immunol.* **2023**, *65*, 148–165. [CrossRef]
89. European Parliament and Council of the European Union. Regulation (EC) No 1924/2006 on Nutrition and Health Claims Made on Foods. *Off. J. Eur. Union* **2006**, *L404*, 9–25. Available online: https://eur-lex.europa.eu/eli/reg/2006/1924/oj (accessed on 1 August 2025).
90. Hill, C.; Guarner, F.; Reid, G.; Gibson, G.R.; Merenstein, D.J.; Pot, B.; Morelli, L.; Canani, R.B.; Flint, H.J.; Salminen, S.; et al. The International Scientific Association for Probiotics and Prebiotics consensus statement on the scope and appropriate use of the term probiotic. *Nat. Rev. Gastroenterol. Hepatol.* **2014**, *11*, 506–514. [CrossRef]
91. Markowiak, P.; Śliżewska, K. Effects of probiotics, prebiotics, and synbiotics on human health. *Nutrients* **2017**, *9*, 1021. [CrossRef]
92. Reid, G. Probiotics: Definition, scope and mechanisms of action. *Best Pract. Res. Clin. Gastroenterol.* **2016**, *30*, 17–25. [CrossRef] [PubMed]

93. Sanders, M.E.; Levy, D.D. The Science and Regulations of Probiotic Food and Supplement Product Labeling. *Ann. N. Y. Acad. Sci.* **2011**, *1219*, E1–E23. [CrossRef]
94. Taylor, S.L.; Hefle, S.L. Food allergen labeling in the USA and Europe. *Curr. Opin. Allergy Clin. Immunol.* **2006**, *6*, 186–190. [CrossRef]
95. Huang, H. Comparative analysis of pre-packaged food labeling regulations between China, the European Union and the United States. *Lect. Notes Educ. Psychol. Public Media* **2024**, *77*, 27–33. [CrossRef]
96. Čapla, J.; Zajác, P.; Ševcová, K.; Čurlej, J.; Fikselová, M. Overview of the milk and dairy products legislation in the European Union. *Legestic* **2023**, *1*, 1–16. [CrossRef]
97. Greenpeace. Dairy Industry Greenwash Under Fire as Lawsuits Go Global. 2025. Available online: https://www.greenpeace.org/aotearoa/press-release/dairy-industry-greenwash-under-fire-as-lawsuits-go-global/ (accessed on 1 August 2025).
98. Doshi, S.; Jangir, S.; Gohil, P. Role of blockchain technology in enhancing supply chain traceability, transparency and efficiency. *J. Exp. Agric. Int.* **2024**, *46*, 636–653. [CrossRef]
99. Zelbst, P.J.; Green, K.W.; Sower, V.E.; Bond, P.L. The impact of RFID, IIoT, and blockchain technologies on supply chain transparency. *J. Manuf. Technol. Manag.* **2020**, *31*, 441–457. [CrossRef]
100. Melissari, F.; Papadakis, A.; Chatzitheodorou, D.; Tran, D.; Schouteten, J.; Athanasiou, G.; Zahariadis, T. Experiences using Ethereum and Quorum blockchain smart contracts in dairy production. *J. Sens. Actuator Netw.* **2024**, *13*, 6. [CrossRef]
101. Biradar, M.; Sidnal, N.; Rokade, R.; Shiragapur, B. Dairy product quality evaluation using optimization-based deep maxout network with blockchain-driven internet of things. *Peer-to-Peer Netw. Appl.* **2025**, *18*, 124. [CrossRef]
102. Lau, S.; Wiedmann, M.; Adalja, A. Consumer perceptions of QR code technology for enhanced fluid milk shelf-life information provision in a retail setting. *JDS Commun.* **2022**, *3*, 393–397. [CrossRef]
103. Rotsios, K.; Konstantoglou, A.; Folinas, D.; Fotiadis, T.; Hatzithomas, L.; Boutsouki, C. Evaluating the use of QR codes on food products. *Sustainability* **2022**, *14*, 4437. [CrossRef]
104. El Amine, B.M.; Lamia, S.-T. Blockchain adoption for a sustainable agricultural supply chain: Opportunities and challenges for the dairy industry. In Proceedings of the 2023 International Conference on Decision Aid Sciences and Applications (DASA), Annaba, Algeria, 4–6 November 2023; pp. 331–336. [CrossRef]
105. Fonseca, T.F.A.; Garrocho, C.T.B. Towards a milk quality recording and monitoring system based on blockchain and long-range internet of things. In Proceedings of the Workshop em Blockchain: Teoria, Tecnologias e Aplicações (WBLOCKCHAIN), Niterói, RJ, Brazil, 24 May 2024; pp. 1–14. [CrossRef]
106. Joseth, G.; Lorena, A.; Lucas, P. Transformation of the dairy supply chain through artificial intelligence: A systematic review. *Sustainability* **2024**, *17*, 982. [CrossRef]
107. Hassoun, A.; Garcia-Garcia, G.; Trollman, H.; Jagtap, S.; Parra-López, C.; Cropotova, J.; Bhat, Z.; Centobelli, P.; Aït-Kaddour, A. Birth of Dairy 4.0: Opportunities and challenges in adoption of fourth industrial revolution technologies in the production of milk and its derivatives. *Curr. Res. Food Sci.* **2022**, *7*, 100535. [CrossRef] [PubMed]
108. Vasileiou, M.; Kyrgiakos, L.S.; Kleisiari, C.; Lappas, P.Z.; Tsinopoulos, C.; Kleftodimos, G.; Ntemou, A.; Kateris, D.; Moulogianni, C.; Vlontzos, G. Digital transformation of food supply chain management using blockchain: A systematic literature review towards food safety and traceability. *Bus. Inf. Syst. Eng.* **2025**, 1–28. [CrossRef]
109. Apeh, O.O.; Nwulu, N.I. Improving traceability and sustainability in the agri-food industry through blockchain technology: A bibliometric approach, benefits and challenges. *Energy Nexus* **2025**, *17*, 100388. [CrossRef]
110. Khichi, T.; Prasad, H. Optimizing dairy supply chain system through blockchain technology and just-in-time (JIT) practices. *J. Sci. Agric. Eng. Res.* **2024**, *11*, 303–308.
111. Verna, E.; Genta, G.; Galetto, M. Enhanced food quality by digital traceability in food processing industry. *Food Eng. Rev.* **2025**, *17*, 359–383. [CrossRef]
112. Ran, Y.; Nilsson Lewis, A.; Dawkins, E.; Grah, R.; Vanhuyse, F.; Engström, E.; Lambe, F. Information as an enabler of sustainable food choices: A behavioural approach to understanding consumer decision-making. *Sustain. Prod. Consum.* **2022**, *31*, 642–656. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.