PLANT SCIENCE TODAY
Vol 12(sp1): 1-13
https://doi.org/10.14719/pst.8578

eISSN 2348-1900

REVIEW ARTICLE

Strategic labelling of alternative protein foods and beverages for consumer clarity

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Received: 29 March 2025; Accepted: 27 May 2025; Available online: Version 1.0: 07 October 2025

Cite this article: Gokulan N, Moghana LS, Mahendran K, Amuthaselvi G, Davamani V. Strategic labelling of alternative protein foods and beverages for consumer clarity. Plant Science Today. 2025; 12(sp1): 1-13. https://doi.org/10.14719/pst.8578

Abstract

This review examines effective labelling techniques for foods and beverages with alternative proteins, emphasizing their impact on dietary choices and consumer behaviour. It explores key aspects such as protein composition, health claims and sustainability indicators, integrating previous research to assess how labelling influences consumers' choices between plant-based substitutes and animal products. The findings suggest that clear and accurate labelling is essential for consumers to make informed decisions that align with environmental and health goals. However, the review highlights inconsistencies in regional regulatory frameworks, particularly regarding protein labelling norms. Additionally, it underscores the potential of underutilized, high-protein plant sources as effective alternatives in plant-based products. This study provides a closer examination of how food and beverage labels, particularly those for alternative protein products, are used and understood globally. Using the PRISMA framework, this paper systematically reviewed 42 peer-reviewed studies from the Scopus database. The research goal was to explore not just what the labels say, but how clear, consistent and useful they are for consumers and found that labelling rules often vary between regions, which can create confusion and reduce consumer trust. What sets this review apart is its focus on areas that often receive little attention, such as the mislabelling of protein content, the challenges in agreeing on terms for plant-based foods and the limitations of current front-of-pack labels. By pulling together insights across these underexplored topics, the research suggests ways to improve labelling so that consumers can make more informed, healthier and environmentally conscious food choices. Socially, it promotes the wider adoption of sustainable diets through informed decision-making, while practically, it highlights the role of improved labelling standards in encouraging healthier and more environmentally conscious consumer behaviour.

Keywords: alternative protein labelling; consumer perception; health claims; labelling standards; meat substitutes; plant-based foods; sustainability claims; vegan certifications

Introduction

Most pre-packaged foods and beverages have food labels, that provide vital information to help us make informed decisions about our health. Labels can help customers allocate their spending towards more pleasurable products, which can lead to an improvement in their financial literacy (1). Many nations undergoing a "nutrition transition", shifting from traditional to modern eating habits, have implemented labelling laws (2). Food labels are inexpensive, statutory tools that support national goals of promoting healthy eating and disease prevention. Therefore, ensuring that all food producers provide accurate and consistent nutrition information on their products is essential. Alternative proteins, which replace animal-based proteins, offer the food and beverage industry opportunities to expand, increase profitability, boost competitiveness and foster innovation. Today, there is a notable shift among consumers toward sustainable diets (3). Plant-based protein products have been widely researched, particularly from the consumer perspective, including acceptability, ecological sustainability, technological potential and health impacts (4-7). However, limited research explores how the industry itself perceives and responds to the labelling of plant-based proteins. More specifically, this study identifies the main drivers and barriers to consumer acceptance of plant-based protein products as well as the keywords or phrases that appear on those labels the most frequently. This study aims to examine the design of labels on alternative protein foods and drinks, as well as their effectiveness in conveying key details such as nutrition, health benefits and environmental impact.. It also explores how differences in labelling rules across regions may confuse consumers and how well people interpret what's on the label. Ultimately, the goal is to understand how labelling affects buying decisions, especially for those choosing more sustainable, plant-based diets.

Alternative protein

Numerous vegan groups and consulting firms report a sharp rise in the number of individuals adopting plant-based diets. According to a global poll conducted in 2019, 10 % of consumers avoided red meat, while 40 % of consumers tried to cut back on their intake of animal proteins (8). The market for plant-based milk substitutes has also grown significantly in recent years,

more than tripling in sales globally between 2009 and 2015 to USD 21 billion (9). Vegetarians consume any kind of plant-based diet and abstain from consuming animal products. Whereas the vegan diet excludes all foods and products derived from animals, the vegetarian diet permits the use of eggs, dairy products and honey, as illustrated in Fig. 1.

"Other items, including cheese, egg and fish substitutes, are under development and will be briefly discussed in the innovations section of this study." A wide range of meat and milk alternatives are readily available, widely accepted and utilized in vegetarian and vegan diets. The key components are mushrooms, wheat, gluten and soy. Because soy is rich in protein, essential amino acids and other nutrients, it is commonly used to produce protein-rich foods such as tofu, which is made by pressing and coagulating soy curds into a dense block. Minimally processed forms of soy include soy flour. Soy products are utilized to make soy protein isolate, which consists of 90 % protein and soy texturized vegetable protein consists of approximately 70 % protein. Texturized vegetable protein, a type of soy meat substitute, is often produced through an extrusion process that yields a variety of product sizes and forms (10). Since wheat flour is used to separate the starch, wheat gluten, also known as seitan, is produced and used for its binding, dough-forming and leavening properties. The cohesive and chewy texture of it imparts a meat-like texture to goods made with wheat gluten. For their chewiness, mushrooms are also incorporated into goods (11).

In the development of meat substitutes, legume proteins from peas, lentils, lupines, or chickpeas have also been utilized. The most promising of them is the protein derived from peas. Rapeseed and canola oilseed proteins can be utilized as structural agents that, when heated, provide textures like flesh (12). Table 1 indicates the alternative protein examples (13).

Alternative beverages

Drinks are no longer just thought of as thirst quenchers in the modern world; customers now search for certain functions from their drinks that fit into their daily lives. These drinks' functionality might be to address various requirements and lifestyles to increase vitality, combat ageing, exhaustion and stress. There are numerous opportunities to investigate plant-based substitutes for milk in the production of beverages that resemble milk. Furthermore, over the past several years, plant sources such as grains and legumes have been recognized as functional foods and nutraceuticals due to the inclusion of nutrients, minerals, dietary fibre, vitamins and antioxidants that promote health. Other milk alternatives, such as soymilk, almond milk, hemp milk, peanut milk, rice milk, oat milk, sesame milk, coconut milk and hazelnut milk, are popular due to their health-promoting properties, being rich in vitamins, minerals, antioxidants and often lower in saturated fat compared to dairy milk (14).

Effective labelling importance

Marketing has a significant impact on how people view and accept new meals. Front -of -label claims, pricing and in-store positioning were among the marketing methods that were looked into. One of the most significant and direct channels for consumers to exchange product information is the food label. Food labels should ideally be tools that help people make wise and healthful decisions. Accordingly, food labels have the potential to be effective nutrition communication tools. A study found that nutritional labelling serves three main purposes: first, to provide consumers with basic product information; second, to disseminate health and dietary information and direct food

Table 1. Shows the examples of alternative proteins

Proteins	Origin	Traditional Examples	Novel examples
Plant Protein	Globally in everywhere	Cereals: Wheat, corn and oats Legumes: soy and beans (product called tofu, tempeh	Mock meat-made of soy and gluten, i.e., Beyond Meat and mock chicken
Insect Protein	In African, South American and Asian Countries	Crickets	Bread or biscuits made with cricket flour, insect burger patties
Algal Protein	Traditionally, in Asian countries	Seaweed, Spirulina, *Chlorella*	Food incorporated with Seaweed, Spirulina and *Chlorella*, such as pasta, beverages and desserts.

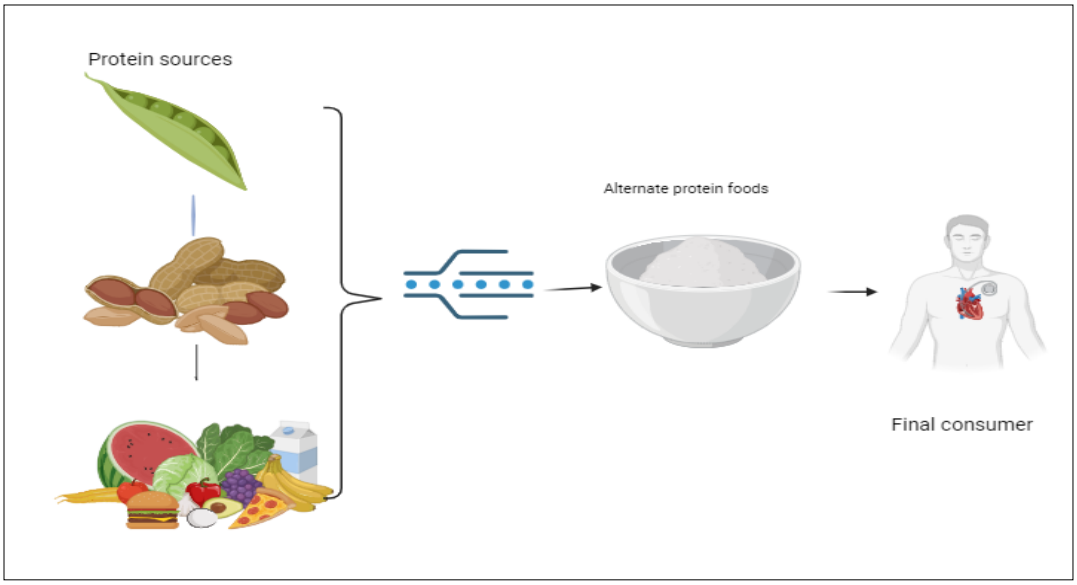

Fig. 1. Source of the alternative proteins.

advertising and marketing (15). Food labels may have the impact of deterring the use of unhealthy foods in an Indian setting, where non-communicable illness,es overweight and obesity are on the rise. This is something that needs to be investigated. In the context of food goods, nutritional value is regarded as a credible characteristic. On the other hand, nutritional labels may serve as a search feature if reliable labels are accessible. In many nations such as Australia and, USA. The regulatory environment has long acknowledged the possibilities of standardized on-pack nutrition facts and has made it mandatory for all processed food products to include nutritional labels. Other organizations, such as the European Union, are considering enacting obligatory nutritional labelling has expanded dramatically in recent years (16).

Label schemes are cost-effective, simple to implement and a non-intrusive regulatory instrument that empowers customers to determine the sustainability of items informing their purchasing decisions. Furthermore, to motivate businesses to enhance their environmental norms. Generally speaking, the word "sustainability label" refers to four dimensions: social factors like fair-trade labels, animal welfare, ethics and health factors like nutrient labels. Examples of environmental friendliness include organic or carbon footprint labels (17, 18).

Clean labels also include information from the back of the package (BOP), such as ingredient lists or nutritional information panels. Clean labelling refers to the use of fewer, simpler, or more naturally occurring substances as opposed to unusual or chemically sounding components. Despite additive dominance, the ingredient list's abbreviation aid in determining the product's naturalness. Nowadays health-related nutrition labels are extensively used on food products. Research indicates that these labels influence customer behaviour, such as changes in what they buy and eat. By boosting the purchase of goods with purported health advantages and decreasing the purchase of foods and beverages high in energy, using environmental impact labelling is one potentially effective way to promote the choice of more ecologically friendly foods (19).

Methodology for literature selection

To assess earlier research, this study used the preferred reporting items for Systematic Reviews and Meta-Analysis (PRISMA) technique, as presented in Fig. 2. The investigation searched the prior literature using the Scopus database. A final list of literature is created by shortlisting the entire list of literature that was retrieved using various inclusion and exclusion procedures. This study analyses the effective labelling practices for alternative protein food and beverage items using a review of 42 studies. The PRISMA graphic displays the various literature elimination patterns. The reviewed literature was carefully categorised into three main themes: the clarity and consistency of regulations, consumer understanding of label information and the implications of those labels. . This helped us identify important gaps in current knowledge, reveal mismatches in labelling practices and identify where regulatory changes could make a real difference.

Results and Discussion

Most relevant sources

The chart shows that journals, particularly "Foods" with most active publications. It is a significant source of information for research on effective labelling of alternative proteins, followed by "Food Quality and Preference" and "Frontiers in Sustainable Food Systems", with six Publications for publishing review literature. These are the key journals to publish in, as shown in Fig. 3.

A FOP nutrition label typology

FOP labels provide customers with condensed nutrition information and serve as a supplement to the more comprehensive NFP, typically located on the side or back of the container. FOP labels fall into one of two general categories: reductive labels and interpretative labels. Reductive labels,

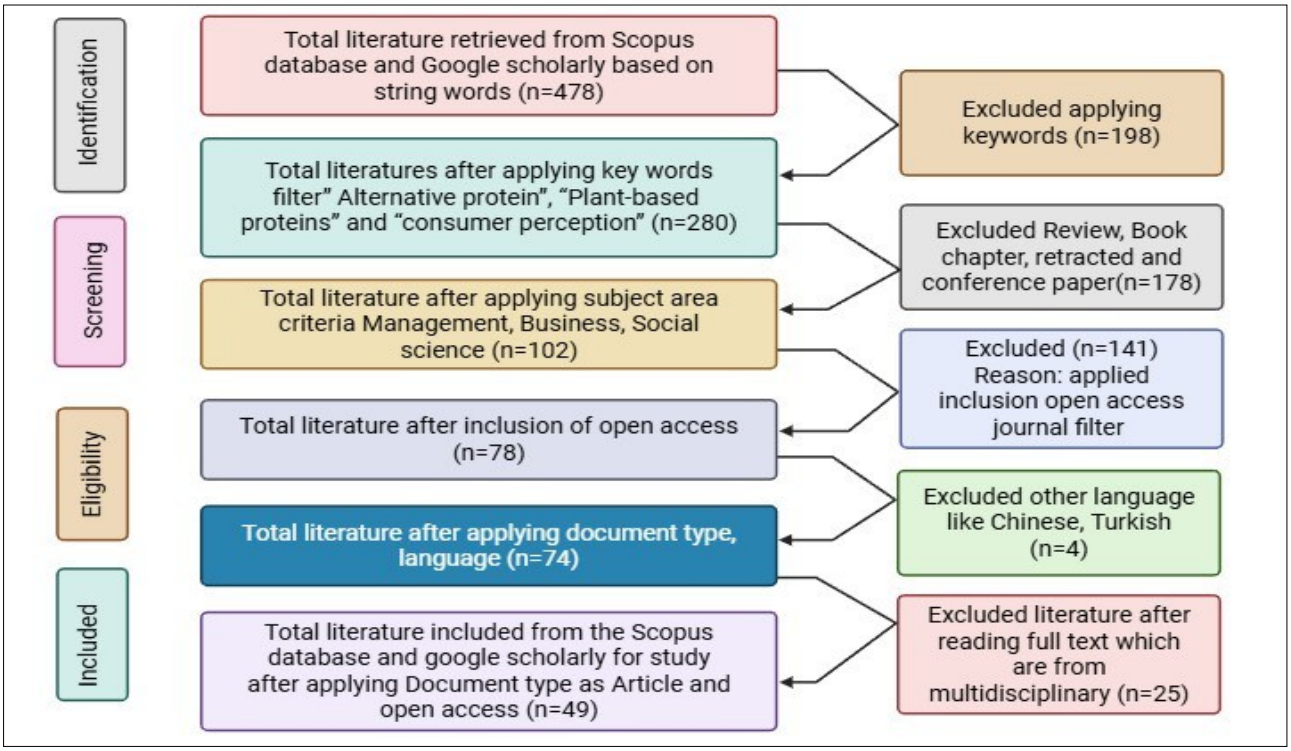

Fig. 2. PRISMA flowchart depicting the search literature for a review of effective labeling practices for alternative protein food and beverage items.

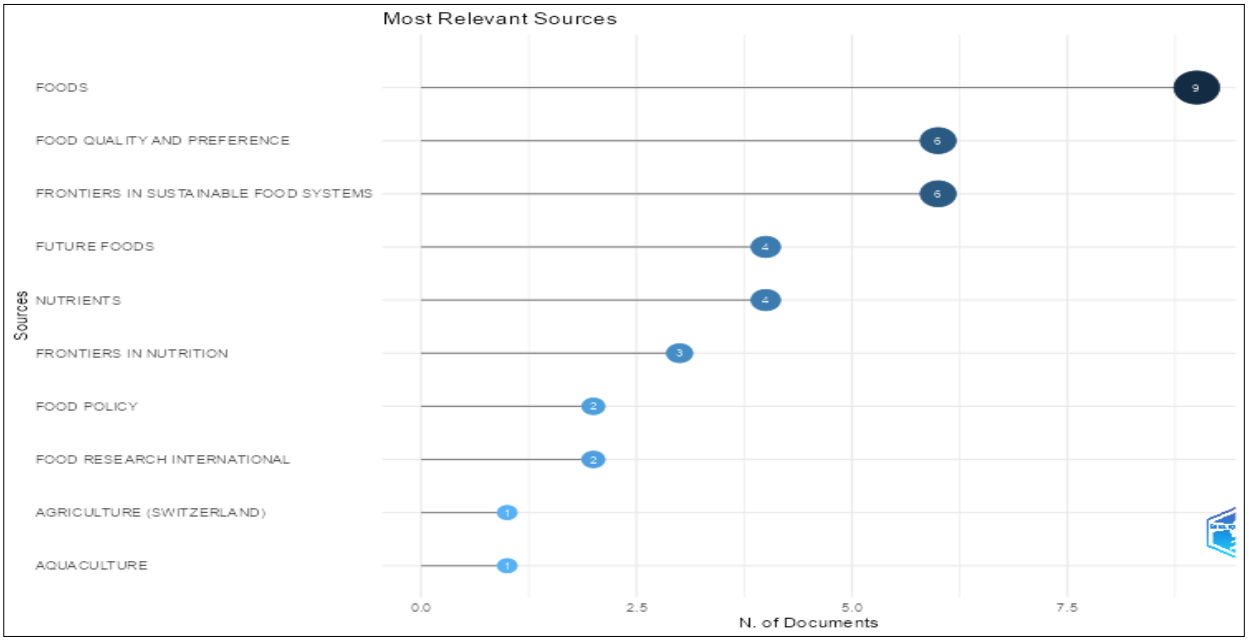

Fig. 3. Most relevant journals in effective labelling practice of alternative protein food and beverage items.

which provide less nutrition information (Facts Up Front, Guideline Daily Amount, etc.) are supplied in the NFP without explaining this data. Interpretative labels (such as warning labels, traffic light symbols, star-based systems and health logos) provide a more thorough assessment of the data in the NFP (20).

Current labelling standards and regulations

Before 2006, the Prevention of Food Adulteration (1954) Act governed the information required on packaged food goods in India. This act required the disclosure of basic information, such as the product name and expiration date, but not nutritional details. All food items are subject to general marketing and food marketing regulations. The Food Information Regulation (EU) No 1169/2011, which outlines labelling guidelines for all foods, is the cornerstone of food legislation in the European Union. The regulation aims to safeguard consumers, promote the internal market and reduce trade barriers. Similarly, the US has strict labelling guidelines that emphasize compliance with legal requirements in both the country of origin and the destination country (14). Food labelling is increasingly essential, especially in enhancing transparency and consumer trust regarding health claims, sustainability indicators and production methods-areas often referred to as "credibility aspects." These aspects enable consumers to make informed decisions, particularly when the information cannot be verified independently (21). By the end of 2022, the European Commission aimed to implement a harmonized labelling system covering the health, environmental and social impacts of food items. This highlights the importance of standardized and transparent labelling systems (22).

Regulation of food marketing

Labelling regulations are now within the purview of the Food Safety and Standards Authority of India, which implemented new packaging and labelling standards in 2011 that mandate the inclusion of essential nutritional content information. Simultaneously, the criteria for nutrition labelling have been changed by Codex Alimentarius, the global regulatory organization overseeing food labelling that was founded in 1963 by the Food and Agriculture Organization and the World Health Organization (Codex Alimentarius). All food marketing is subject to the Food Information Regulation. EU law defines three categories of food names: descriptive, customary and legal.

Regulation of food marketing

Labelling regulations are now within the purview of the Food Safety and Standards Authority of India (FSSAI), which implemented new packaging and labelling standards in 2011. These standards mandate the inclusion of essential nutritional content information. At the global level, the criteria for nutrition labelling have also been revised by Codex Alimentarius, the regulatory organization overseeing international food labelling. Established in 1963 by the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), Codex sets standards to ensure consistency and safety in global food trade. Within the European Union, food marketing is governed by the Food Information Regulation, which categorizes food names into three types: descriptive,

Required indicators include

The food's name, together with any relevant details about its physical state or any processing it may have undergone. Such as powdered, frozen, refrozen, freeze-dried, concentrated and smoked. The nutrition statement, the name and address of the Food Business operator (FBO), the list of ingredients (arranged in descending weight order); the net quantity (stated in litres, centilitres, millilitres, kilograms, or grams); the usage instructions; the date of minimum durability, also known as the "use by" date; and, if frozen food is involved, the date of freezing (EU/1169/201).

Legally, some food names are allowed for that specific criterion. Such as milk products, which are made of mammary secretions, are designated with terms such as cheese, cream and milk. The European Court of Justice has addressed the naming of vegan dairy replacement. According to the "Tofu Town" case reserved that dairy names cannot be used, not even in conjunction with descriptors like "vegan" or "plant-based". The judgement was justified by the fact that EU treaties grant the Union broad authority to accomplish the goals outlined in the Common Agricultural Policy (FAP). The EU regulation on the names of milk products grants exceptions for products of the exact nature, which is clear from traditional usage. Examples include 'almond milk' and 'coconut milk' (23).

Environmental assertions

The EU has the organic food regulations (EU/2018/848) for low-carbon and other eco-friendly food. An essential component of organic food is limiting the use of synthetic pesticides, herbicides and fertilizers. Compared to regular food, there is a narrower list of permitted additions. Any environmentally friendly production or resource-efficient process cannot be referred to be organic since organic food is a specially designated regulatory category. Furthermore, only organic food is permitted to use the term or prefix “bio”. Genetically modified foods do not meet the EU’s definition of organic foods, even if they may have advantages for the environment (23).

Factor analysis

From the radar chart, by analysing the positioning and clustering of the various terms in the four quadrants, the upper right quadrant indicates sensory attributes like taste and food preference and the upper left quadrant indicates environmental impact and ethical concerns and the lower quadrant indicates nutritional information, cultural demographics and cultural factors. The radar chart highlights the multifaceted nature of effective labelling for alternative protein foods as depicted in Fig. 4.

Challenges in labelling alternative proteins

There are many difficulties in labelling food items and drinks with alternative protein sources. Among these difficulties is the requirement for precise and unambiguous labelling to help people with diseases like phenylketonuria (PKU) determine protein exchanges (24). The need to go towards clean label products to address problems like the lack of legal definitions and customer perceptions and the ongoing disagreement over the use of terminology associated with meat in the labelling of non-meat goods, which has left customers perplexed and given rise to legal issues in the US and EU, careful consideration of supplementation, amino acid profiles and bioavailability is necessary to design alternative protein products with appropriate nutritional profiles. To overcome these obstacles, it is necessary to strike a balance between informing customers accurately and adhering to regulations, all the while guaranteeing the safety and nutritional value of alternative protein products (25).

Principal problems with protein labelling

It was reported that protein analyses were either printed in a linear style with other nutrients listed on the same line, making it impossible to identify protein from other nutrients, or that protein data were lost or concealed in packaging folds. Concerns over the protein labelling of foods imported were also significant. US food labels only list the protein amount for portion sizes. Food labels on imported goods from the USA only list protein as present if a pre-packaged product contains more than 1g of protein per part; if not, they falsely claim that the product has 0 g of protein per portion. It has been claimed that certain imported items do not have food analysis written in English on the labels, even though all labels must adhere to UK food labelling regulations (24). The timeline of labelling regulation is shown in Fig. 5.

The conventional animal agriculture industry's aversion to labelling alternative proteins creates regulatory obstacles, which in turn causes disagreement over the use of terminology like “meat” and “dairy” on the labels of alternative foods (26). The regulatory environment is more complicated by safety concerns regarding alternative protein sources, such as allergens, anti-nutrients and microbiological hazards, which call for strict quality control procedures (27). To minimize misunderstanding and avoid legal issues, alternative food labels must adhere to uniform regulations that take customer perceptions into account. To further link technical improvements with regulatory needs, extensive research on alternative proteins is being conducted to push for the development of stringent safety standards. To successfully

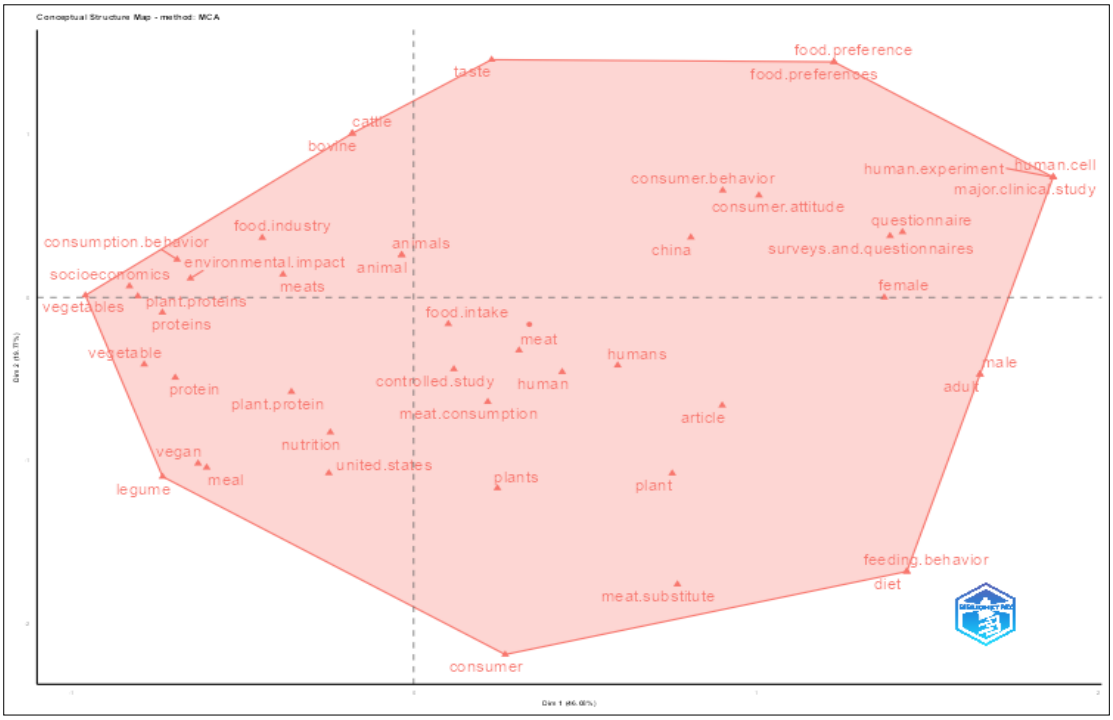

Fig. 4. Shows factor analysis of positioning and clustering of various keywords to underscore the effective labelling practice of alternative protein food and beverage items.

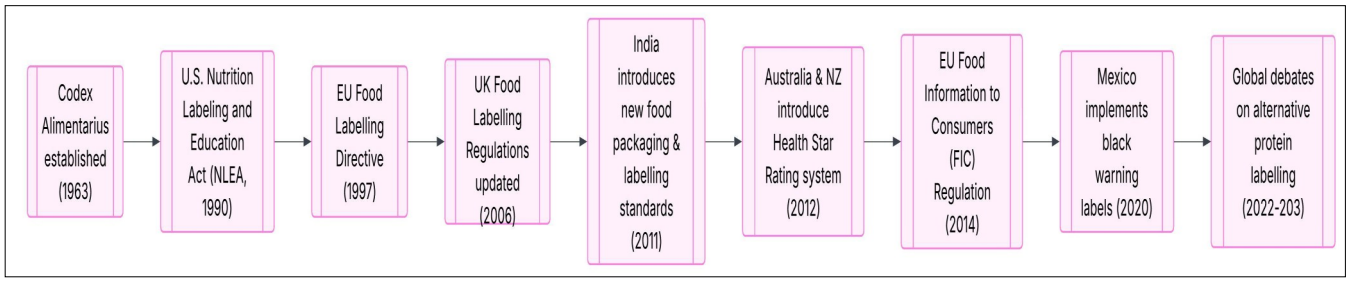

Fig. 5. Timeline of labelling regulations in different nations.

incorporate alternative proteins into the food industry while maintaining consumer safety and regulatory compliance, these issues must be resolved (25).

Companies may also be hindered by the EU's regulatory framework for alternative protein sources since they must follow the rules for alternative product labelling to sell their goods in the EU. Frequently, the law may be difficult to understand and perplex a customer. For instance, phrases about traditional animal products may not be mentioned on the labels of the vegetable alternatives for dairy products, but they may be on the labels of vegetable substitutes for meat. This might lead to misconceptions, which, when paired with the rising demand for "clean" labelling on low-processed and non-processed food products, could incur additional expenses and raise the price of the finished product.

Bibliometrix

Keyword co-occurrences

The keyword co-occurrence in Fig. 6 network visualization represents the interconnectedness and frequency of key terms associated with the topic of alternative protein food labelling. "Human", "Meat" and "animals" are the central themes in "human" at the centre, which focuses on human consumption, behaviour and attitudes. In the cluster, red indicates plant protein and plant-based protein while the green cluster indicates meat and animals products. The dense interconnections between clusters suggest that the topics are highly interrelated. For example, Concerns about the environmental footprint of meat consumption often coincide with discussions of plant-based protein alternatives and more sustainable dietary choices (28).

Co-citation network visualization

The network visualization in Fig. 7 represents the citation relationships among various academic articles focused on the effective labelling of alternative protein foods. The nodes in the network represent individual articles and the edges (lines) between them indicate citations from one article to another. The size of the nodes reflects the number of times an article has been cited by others within this network, signifying its influence in the field.

Clusters and Themes

Red Cluster

This cluster includes seminal works by authors such as Godfray H.C.J., Poore J. and Van Loo E.J., indicating a focus on the environmental and health impacts of alternative proteins and the broader context of sustainable food systems.

Blue Cluster

Centred on authors like Onwezen M.C. and Siegrist M., this cluster seems to focus more on consumer perception, behavioural studies and the psychological aspects.

Thematic map

Chart Structure

Fig. 8 shows the X-Axis (Relevance Degree/Centrality) which measures the relevance of themes. Y-Axis (Development Degree/ Density): Measures the development and internal cohesion of themes. The Quadrants of Upper Right (Motor Themes) show high relevance and high development, Upper Left (Niche Themes): High development but low relevance, Lower Right (Basic Themes) shows high relevance but low development and Lower Left (Emerging or Declining Themes) shows low relevance and low development. The quadrant chart provides a strategic framework

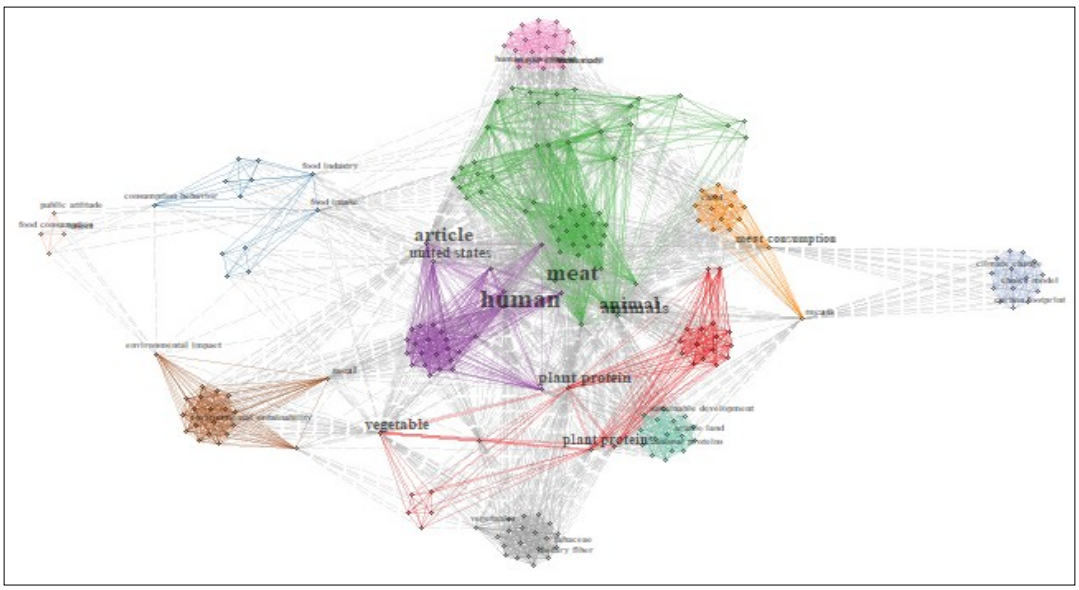

Fig. 6. Keyword co-occurrence network visualization of frequency of key terms.

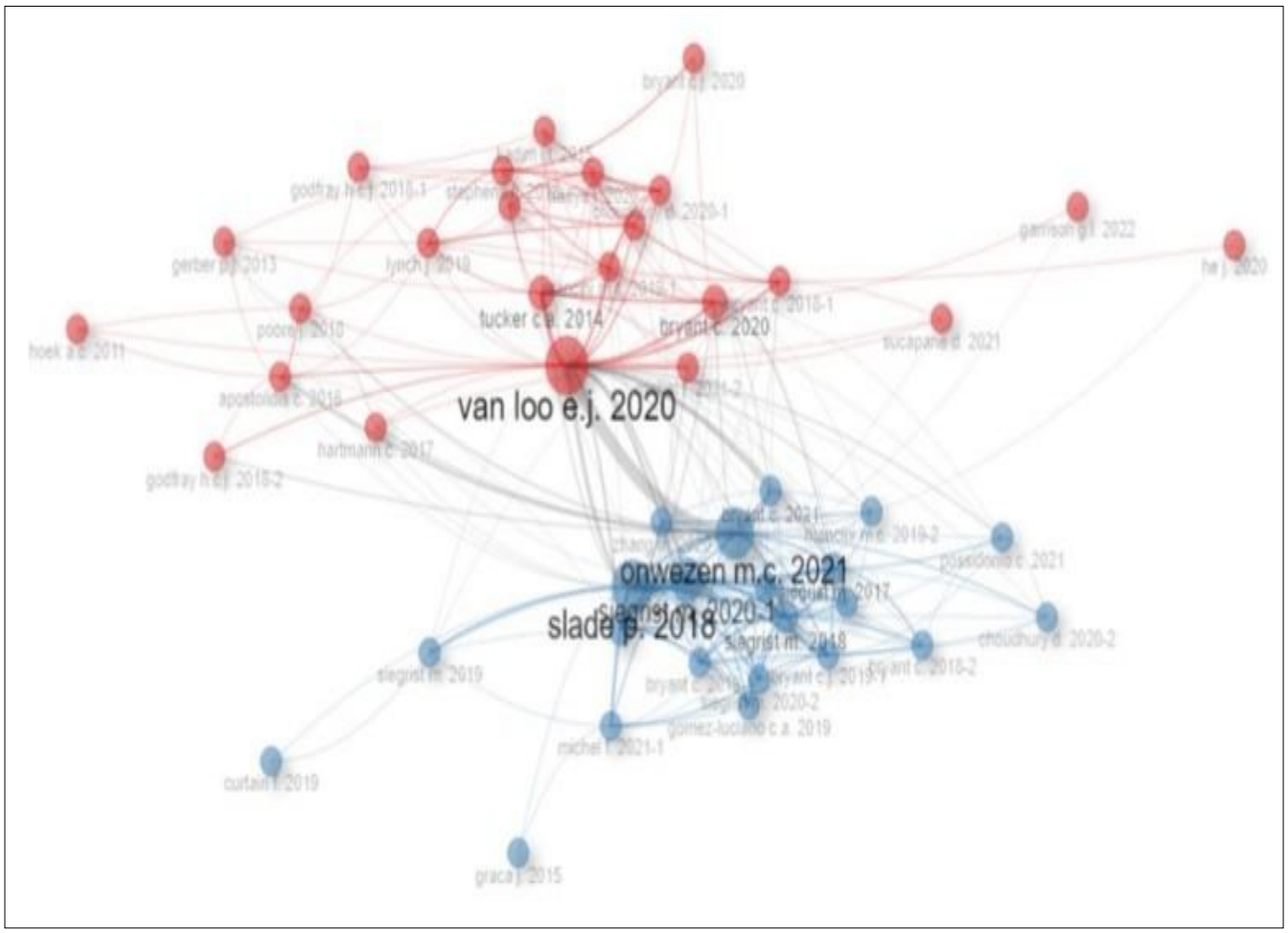

Fig. 7. Co-citation network visualization of citation relationships among various articles.

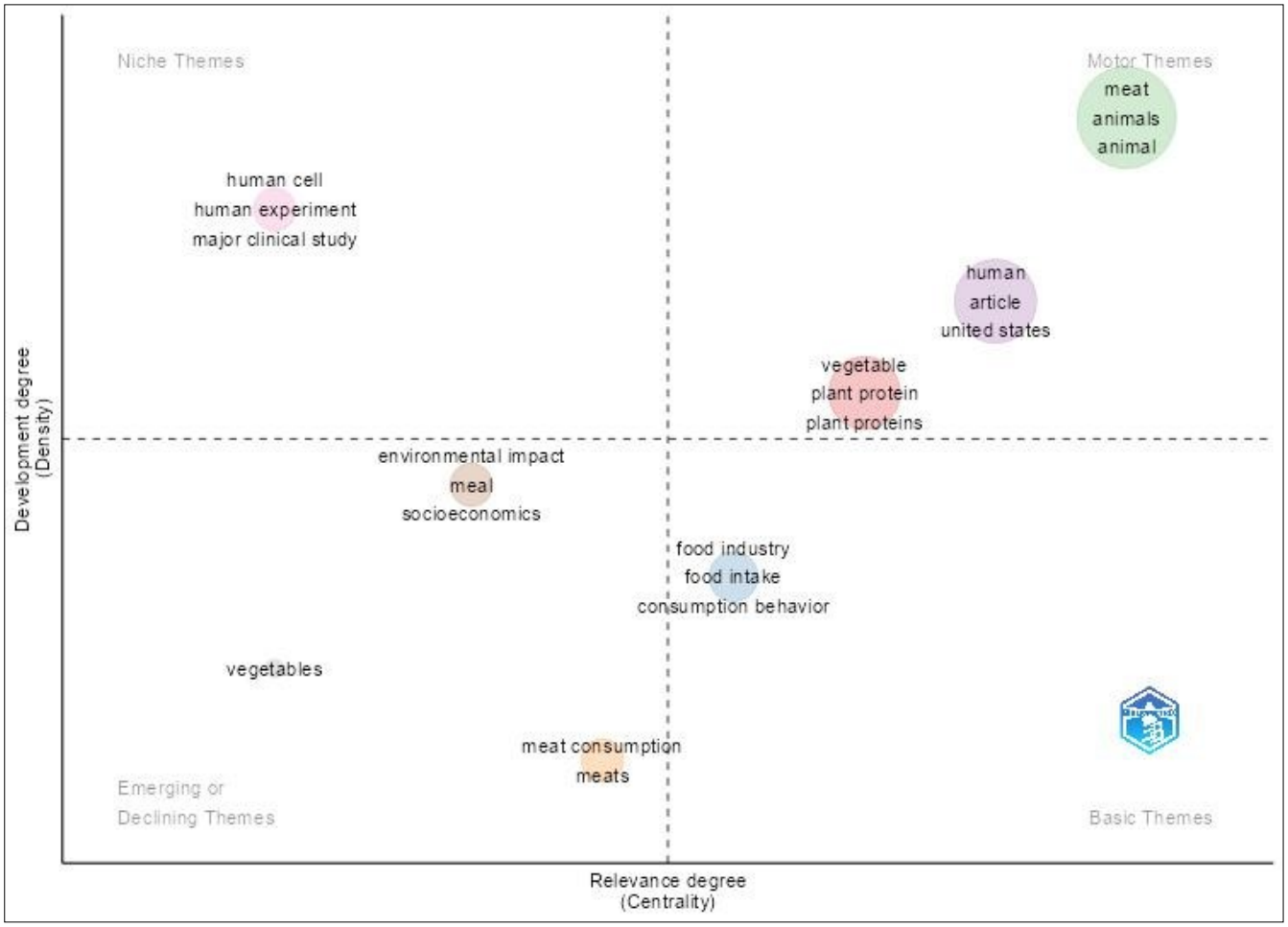

Fig. 8. Thematic map of keyword occurrence in peer-reviewed articles.

for developing effective labels for alternative protein foods. By focusing on motor and basic themes, labels can ensure they address the most relevant and fundamental aspects of consumer interest. Niche themes can be used to enhance credibility and appeal to specific segments, while emerging themes can be monitored for future trends. This approach ensures that labelling is comprehensive, appealing and informative, thereby supporting consumer acceptance and market success for alternative protein products.

The article by Van Loo EJ (2020) in "Food Policy" with a maximum citation of 235 is highly influential in the field and most cited global document (Fig. 9). It likely addresses key aspects of food policy related to alternative protein labelling, followed by Beacom E (2021) in J Food prod mark with next maximum of 26 citations which focuses on marketing strategies and consumer responses to labelling. These articles provide a key insight into consumer behaviour and practical applications of labelling.

Best practices for labelling

Clear and educational packaging techniques are part of best practices for labelling foods and drinks with alternative protein sources. Consumer acceptability is greatly influenced by marketing promises about protein content, nutritional content and wellness are frequently included in front-of-pack labels. Labelling alternative items with dietary patterns like "vegetarian" and "plant-based" should emphasize familiarity and comfort for customers (29). But there are disagreements about how alternative meals should be labelled, particularly when it comes to using the term "meat" on labels for goods that don't include typical dairy or meat components. Different countries have different regulations for the labelling of food, including beverages. For example, some jurisdictions have guidelines about the addition of vitamins and minerals, while others have none at all (30). To guarantee openness and customer comprehension, food and beverage labels about health must be closely monitored. Labelling alternative protein goods may increase customer confidence and help consumers make educated decisions by including clear nutritional content information, stressing dietary patterns and regulations (31, 32). Manufacturers are increasingly using health-related food labels to highlight beneficial attributes. Some professionals have expressed concerns about the nutritional quality of their goods. A health-related claim might create a halo effect, leading consumers to regard items with the claim as healthier. It suggests that "organic label" might impact customer perception of a product's nutritional quality. When a promise such "low fat" appears on the FOP label, consumers spend less time examining nutritional information and are more likely to rely on their purchase choice (33-35).

Acceptance of plant-based protein products by consumers

Motivating elements

The creation of substitute protein sources that share organoleptic properties with meat and other animal products will make them more recognizable to consumers who want to consume less meat but view these substitutes as far-off and foreign. But organizations and vegetarian customers disagree with this viewpoint and are drawn to non-conventional food items that are entirely distinct from the former (36).

Concerns for animal welfare are the primary driving force for customers who adhere to a strict vegetarian diet. Consequently, manufacturers of goods containing alternative protein sources must capitalize on the aforementioned elements to inform customers, raise knowledge and alter their dietary patterns through educational initiatives (37, 38).

Comparing labels with information on the plant sources of the proteins to those with remarks about the lack of meat increases people's incentives to buy and eat the products for vegetarian customers. Additionally, customers are more likely to make a purchase when higher protein and fiber content is mentioned rather than when the word "without" is used to denote the absence of a certain item (36).

Obstructive elements

People choose plant-based protein products for a variety of reasons and recent research highlights both what attracts consumers and what holds them back. Health is the top motivator; nearly half (49.17 %) of the people surveyed said they choose plant-based options mainly for health reasons. Taste and texture, also known as organoleptic qualities, were the second most important factor (21.67 %). Other reasons included concern for animal welfare (9.17 %), environmental benefits (7.58 %) and product pricing (7.5 %). A few people also mentioned convenience in preparation (0.83 %) and simple curiosity (4.17 %) as reasons for trying these products, as shown in Fig. 10 (39).

On the other hand, some common reasons why people are hesitant to adopt plant-based proteins include not knowing about the health benefits of cutting back on animal-based foods. 38.33 % of people said they weren't aware of these benefits. Another 25 % said they just didn't want to change their current eating habits. Some were concerned about taste or texture (23.33 %), while others pointed out the higher prices of these products (16.67 %). Limited availability (5.83 %) and fear of trying unfamiliar foods (3.33 %) were also mentioned in Fig. 11 (39).

Labels on these products also matter a lot. When asked what words should appear on packaging, most respondents said they preferred "plant-protein" (36.67 %), followed by "plant-based" (31.67 %) and "vegan" (11.67 %). Terms like "meat-free" and "clean-protein" were less popular, as shown in Fig. 12**.** As for phrases, people were most drawn to labels that said "High in plant protein" (54.17 %). Other appealing phrases included "high in fiber" and "no genetically modified ingredients" (10.83 %). Phrases like "low sugar," "low saturated fat" and "natural sweeteners" were mentioned by fewer people, as shown in Fig. 13**.** People are more likely to try plant-based protein products when they know they're good for their health, taste good and are affordable. Clear and appealing labels can also make a big difference in helping consumers feel confident about their choices and encouraging them to try something new (39). Enhanced customer labels make it easier for people to choose food by giving extra information. This is especially helpful for those with health problems like diabetes or high blood pressure. Disruptive purchase habits occur when nutrition information is readily available and easily viewed, causing customers to rethink their decisions at the time of sales and increasing the possibility that they will choose healthier options. Higher Health Star rating products have a competitive advantage, which encourages food manufacturers to restructure their products to improve their nutritional profiles. This eventually improves customer choices and health outcomes. When deciding between dairy substitute

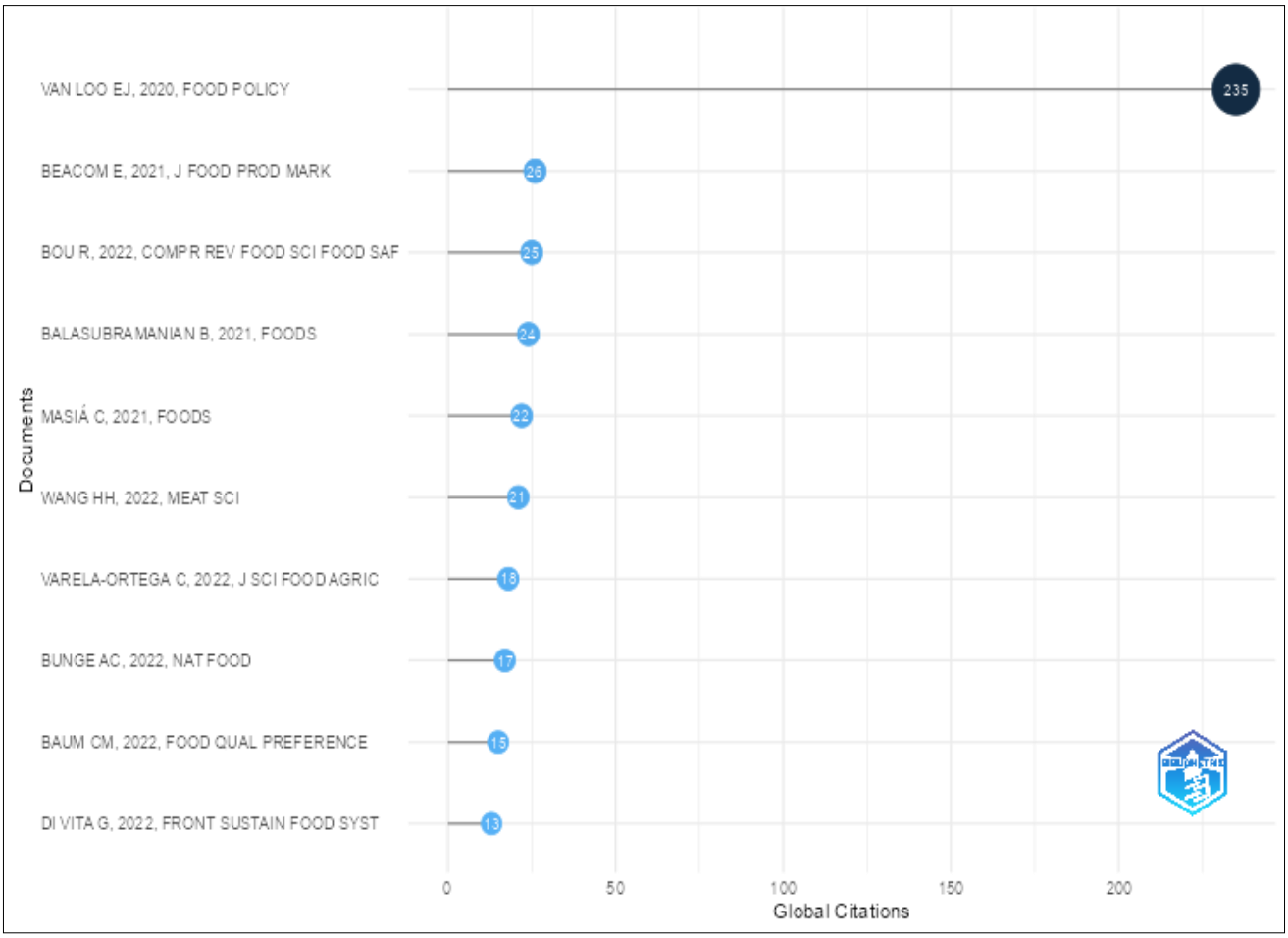

Fig. 9. Most globally cited articles in effective labelling practice of alternative protein food and beverage items.

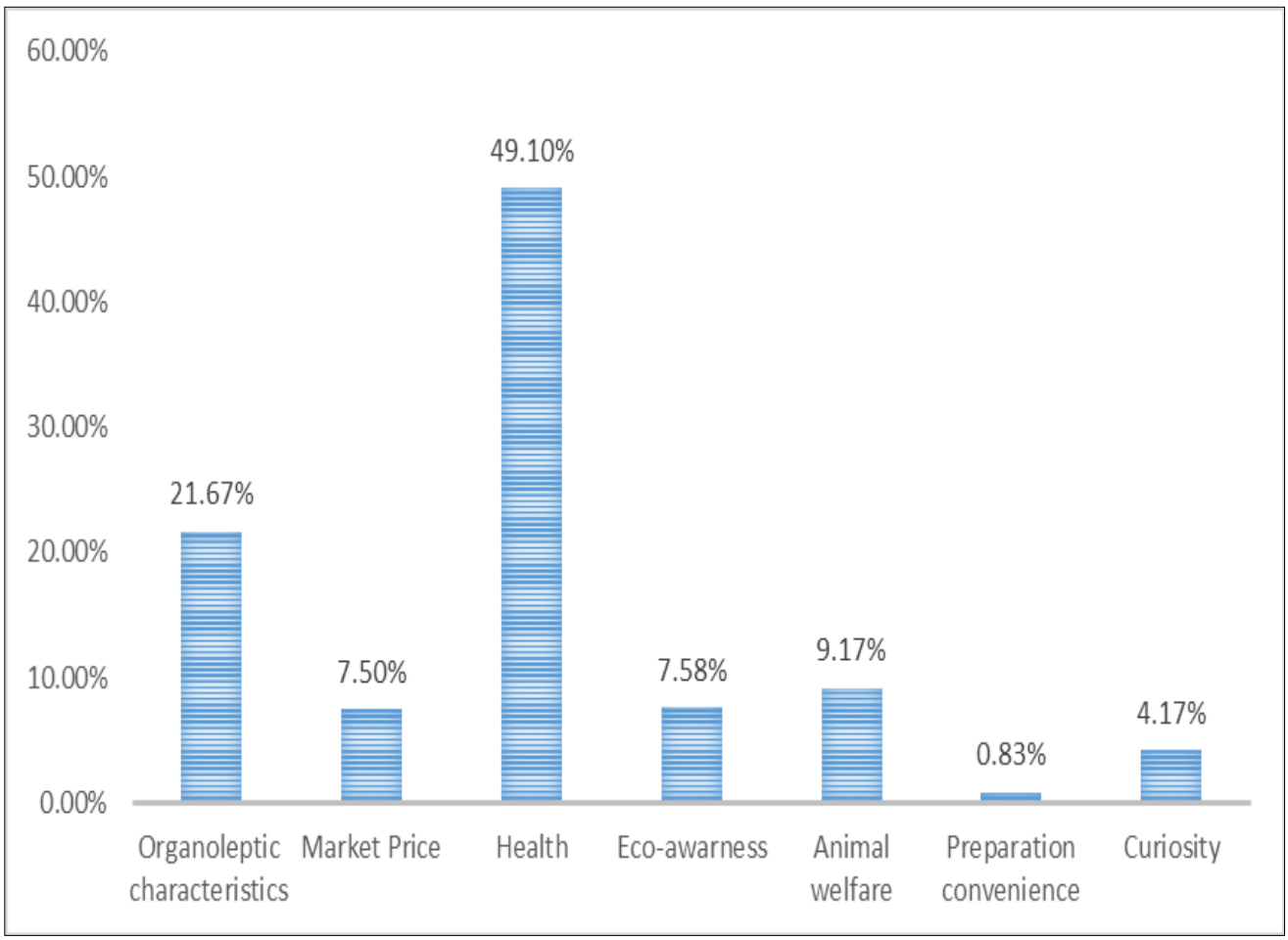

Fig. 10. Consumer drivers for the preference towards the label (39).

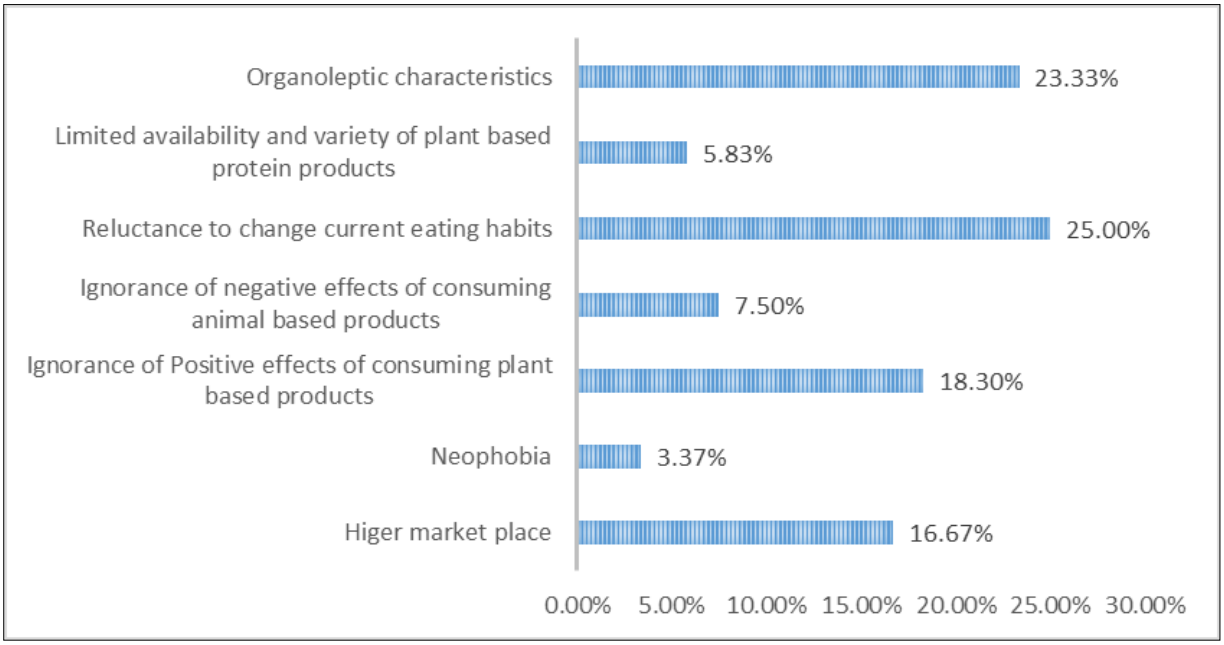

Fig. 11. Consumer acceptance of plant-based protein products (39).

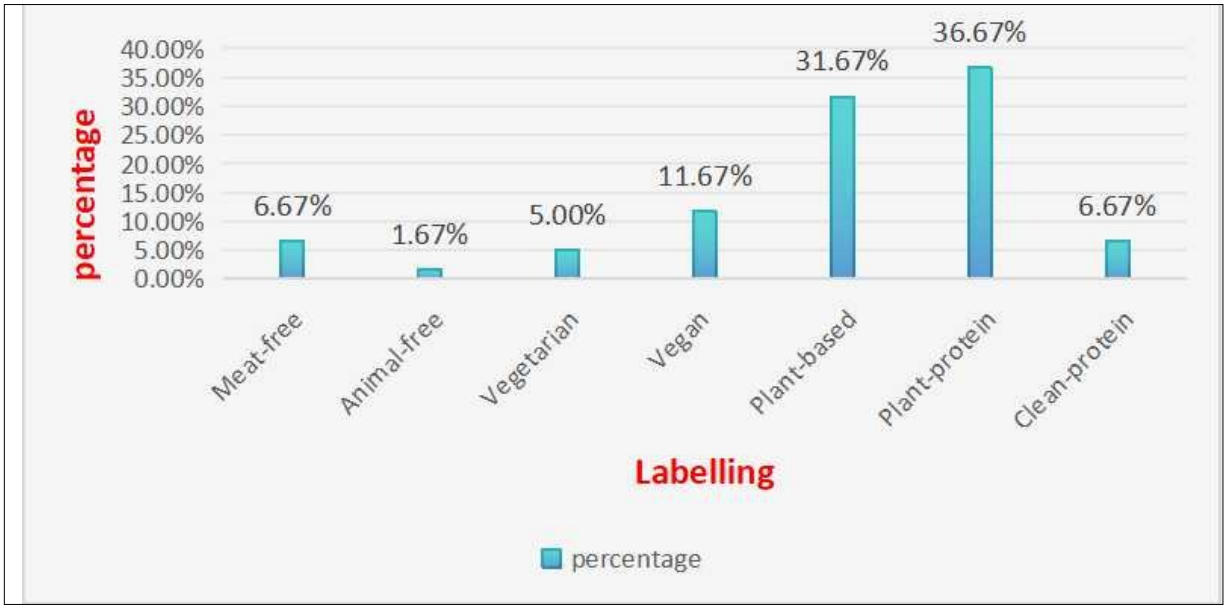

Fig. 12. Choice of words in the labelling of plant-based products (39).

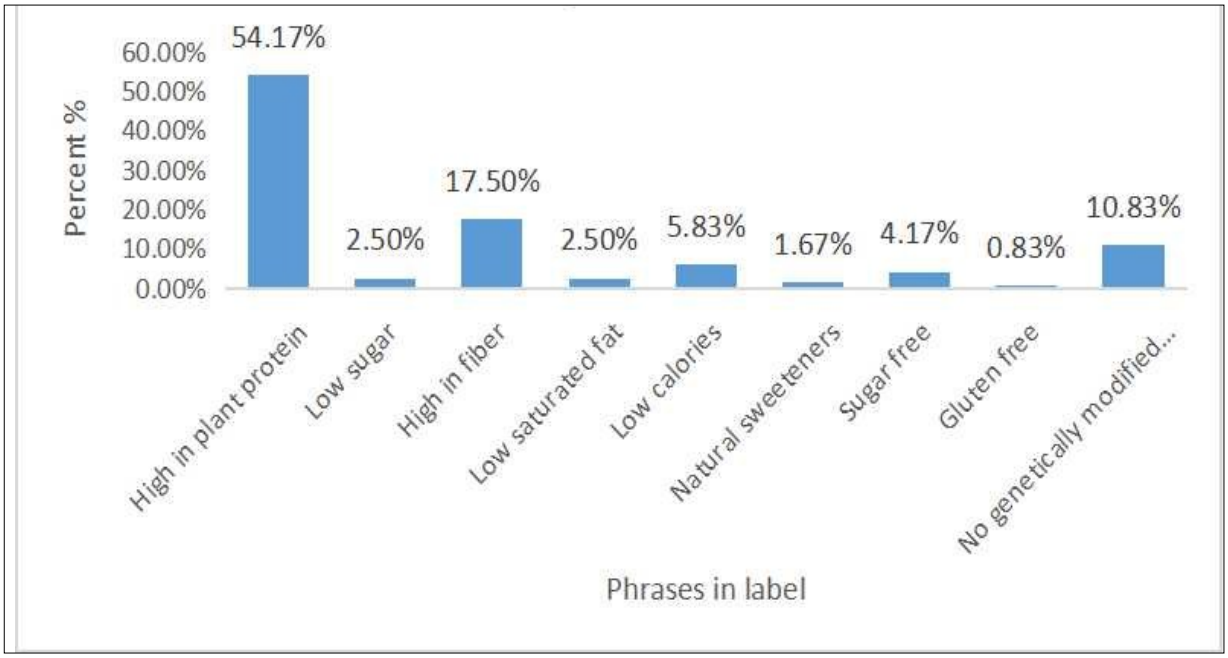

Fig. 13. Choice of phrases for labels of plant-based protein products (39).

beverages and regular milk, consumers place the most emphasis on nutritional characteristics; the most highly valued characteristics are calories, protein, fat, vitamin A and Vitamin D, Protein is the nutritional feature that consumers value the highest out of all, Which suggests that it has a big impact on consumer preferences and willingness to pay for dairy substitute beverages. When making judgments, customers also consider other elements like brand, package size and multipack possibilities, indicating that these characteristics influence consumer preferences for dairy substitute beverages (40).

Word frequency over time: In Y-Axis, (Cumulative Occurrences): The cumulative occurrences of terms over time. In X-Axis, (Year): The timeline from 2020 to 2024.Terms Analysed: The chart tracks several terms related to alternative proteins, such as "ADULT," "ANIMAL," "ANIMALS," "ARTICLE," "CONSUMER ATTITUDE," "CONSUMER BEHAVIOR," "FEMALE," "HUMAN," "HUMANS," and "MEAT."

Most Frequently Used Terms

"HUMAN" and "CONSUMER BEHAVIOR" are the most frequently occurring terms by 2024, suggesting that research and discussions are heavily focused on the human aspect and consumer reactions to alternative proteins. The increasing trend in the usage of terms related to consumer behaviour, human aspects and demographic specifics highlights the need for an informed and strategic approach to labelling alternative protein foods. Effective labelling should address consumer values, provide clear and transparent information and tailor messaging to specific demographics to enhance acceptance and preference for alternative proteins which as shown in Fig. 14**.**

Prospects and technological advancements

Transparency in nutritional information

More and more protein-rich product labels are containing comprehensive nutritional data, such as protein content, amino acid profiles and allergy information.

Plant-based protein smart labels

The applications of smart labels and QR codes on plant-based protein products to provide customers with information about sourcing, processing techniques and sustainability policies have been made possible by technological improvements.

Blockchain technology

Using blockchain technology in food labelling guarantees traceability and transparency in the sourcing and production process.

Protein food labels

Protein food labels frequently have sustainability certificates on them to let customers know how the product and its manufacturing methods (41).

Conclusion

Accurate labelling of alternative protein meals and beverages is critical since online grocery websites sometimes include inadequate, misleading, or false information regarding their protein content is interpreted and understood. Protein is the limiting factor in plant-based milk replacement, with most products containing less protein than regular milk, with the exception of soy and pea-based products. Given that these plant-based milk alternatives are used as milk substitutes, proper content and quality are critical. A significant opportunity exists in harnessing underutilized, protein-rich vegetable resources that can adapt to changing climatic circumstances. Combining flours from diverse vegetable grains with certain fermenting microbes may improve the nutritional content and sensory aspects of

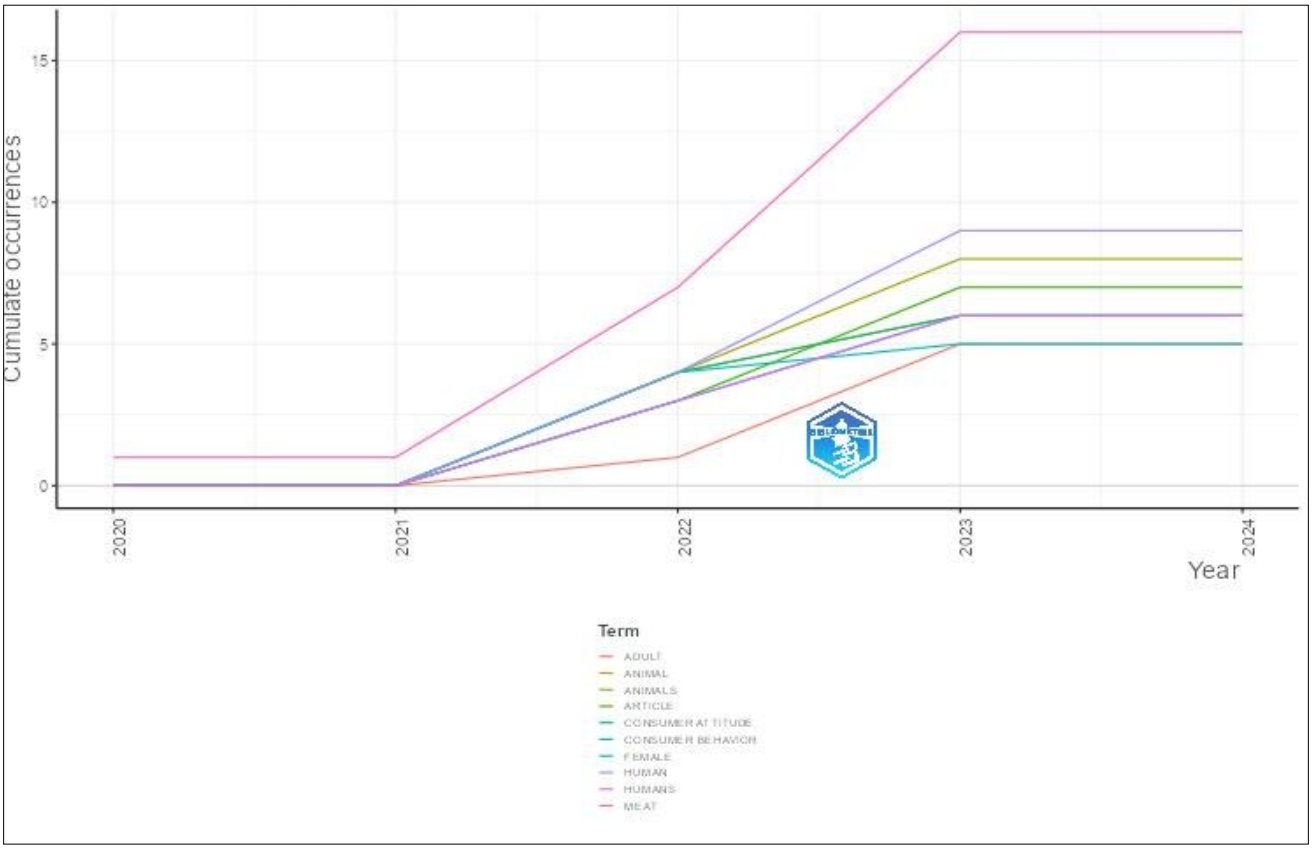

Fig. 14. Word frequency over time.

foods, encouraging their usage as a meat substitute. This strategy enables customers to make educated decisions that lead to considerable reductions in carbon emissions. As a result, proper and accurate labelling of alternative protein foods and beverages is required to assist customers in making healthier and more ecologically responsible decisions. This is especially difficult if labelling remains optional, as manufacturers of high-emission items may be less willing to supply thorough information. Improving label accuracy and completeness will assist customers in choosing replacements that suit their nutritional needs while also aligning with environmental goals.

Acknowledgements

We sincerely thank the guide and Advisory committee members for their invaluable guidance and constructive feedback throughout the review paper. We extend our gratitude to the library and research facilities for providing access to relevant databases. Special thanks to our peers and mentors for their constant support and encouragement. Their collective efforts have greatly enriched the quality of this work.

Authors' contributions

GN participated in article collection, analysed the data, interpreted the findings and formulated the manuscript. MLS contributed by developing the core ideas and reviewing the manuscript. MK assisted in summarizing the content and revising the manuscript. AG contributed to summarizing the manuscript. DV provided additional support and contribution to the research study. All authors read and approved the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

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