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Why can't the alternative become mainstream? Unpacking the barriers and enablers of sustainable protein innovation in Brazil

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ABSTRACT

Animal agriculture and the meat industry raise serious concerns regarding environmental, social, and animal welfare issues. The alternative protein industry has progressed globally, driven by circular economy practices, but the innovations in this industry need to be understood for further advances in circularization. This study examines the key enablers and barriers influencing alternative protein innovation in Brazil—a uniquely positioned country that can lead the global food transition towards alternative proteins. We conducted online semi-structured interviews with 18 experts from organizations operating in the alternative protein sector. The results show that tax incentives, access to funding, and opportunity costs are important external factors that drive alternative protein innovation. Culture, especially related to eating habits and preferences can be used strategically to increase alternative protein consumption in line with the transition to bioeconomy. Human capital, specifically technical and soft skills, matters only when there is access to (financial) resources. Social capital can overcome some barriers by sharing resources, improving partnerships to explore biodiversity, and expanding the entrepreneur network. Many of the barriers and enablers identified takes the form of a public problem, in which the organizations and stakeholders should develop a shared understanding about the most sensitive and urgent topics requiring action. We contribute to the literature on sustainable food systems and circular agri-food chains by providing insights into how to incentivize and streamline the consistent development of innovative products and technologies in Brazil by informing both overarching public policies and sector practices.

1. Introduction

The production and consumption of sustainable proteins is a pressing issue. The current standards of protein production and western diets cannot keep up with the daunting challenge of feeding 10 billion people by 2050. On the one hand, viable alternatives must be produced if we are to achieve the Sustainable Development Goals and targets put forth by the Paris Climate Accords (World Economic Forum, 2019). On the other hand, according to the Food and Agriculture Organization (FAO), about 820 million people suffered from chronic undernourishment in 2018, with the majority living in low- and lower-middle-income countries (FAO, 2020a, 2020b). The United Nations reports that nearly 30 % of all food produced worldwide, representing more than US$1 trillion and 1.3 billion tons, is either lost or wasted during food production and consumption processes (United Nations, 2019). Land degradation, decreasing soil fertility, unsustainable water use and handling, overfishing, and decimation of the marine environment limit the human capability to supply food (United Nations, 2019).

The meat industry has been under intense scrutiny and pressure due to environmental, ethical, and health concerns. From 2018 to 2020, meat production accounted for >50 % of the greenhouse gas emissions stemming from agriculture (OECD and FAO, 2021) and 14.5 % of the total global greenhouse gas emissions (Takefuji, 2021). Meat production is a key driver of global land-use change, freshwater consumption, and biodiversity loss. High meat consumption levels increase several human health risks, particularly cardiovascular diseases and cancer (Ekmekcioglu et al., 2018; Newton and Blaustein-Rejto, 2021; Poore and Nemecek, 2018). Addressing sustainability issues around meat consumption and production is incredibly challenging. It requires breakthrough innovations due to animal agriculture's central role in many economies, rooted in strong cultural and social traditions (Bryant and van der Weele, 2021). Furthermore, the demand for meat products is

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projected to increase worldwide as the population and wealth grow (Godfray et al., 2018; Herrero et al., 2013; Newton and Blaustein-Rejto, 2021).

As a result, there has been a growing interest in developing innovative technologies and practices for sustainable agricultural production and technological alternatives. The goal is to feed a growing population without exhausting Earth's resources and causing irreversible damage to it (Kinney, 2019; The Danish National Bioeconomy Panel, 2018). Within this context, the circular economy (CE) concept has been one of the key inducers of sustainable innovation. It emerges as a new paradigm that proposes an alternative to the prevailing linear "*take-make-dispose*" industrial logic (Blomsma and Brennan, 2017; Cosenz et al., 2020; Geissdoerfer et al., 2017). The broader CE concept was initially entrenched in highly technical, engineering-oriented industrial sectors, such as machinery, electronics, and automotive. However, the concept has been spreading extensively across sectors rich in biological cycles, such as agri-food systems (Jurgilevich et al., 2016; Miranda et al., 2021), fomenting the emergence of a circular bioeconomy that focuses on the production and use of renewable biological resources and their conversion to value added products while advocating for their cascaded use and the minimization of virgin resources (Morone et al., 2022; Salvador et al., 2021; Stegmann et al., 2020). This focus on renewable biological resources to produce sustainable energy, food and materials – such as biomass gasification (Akbarian et al., 2022), eco-friendly hydrogen (Qureshi et al., 2022) or bioplastics (Ali et al., 2022) - is a key solution to secure the so-called "green transition" (Morone et al., 2022).

Within the context of circular bioeconomy, alternative protein technologies can potentially reduce the environmental and social impacts of existing operations and supply chains. This can enable several CE strategies, while new technological development and increased information sharing act as drivers for CE within and beyond the food sector (FAIRR, 2022; Tura et al., 2019). Conversely, the lack of sufficient information and limited uptake of technologies and technical skills establishes strong barriers to adopting CE-related strategies and technologies (Adams et al., 2017; Jabbour et al., 2017; Tura et al., 2019).

Dubbed the "growth engine of 21st-century food" by specialized analysts, alternative protein is a nascent market. The global market is predicted to reach $17.9 billion by 2025 and $1.1 trillion by 2040, potentially acquiring 60 % of the meat market share (FAIRR, 2022). The vast alternative protein technological landscape can be broken down into different novel ingredient sources that differ significantly in terms of technologies, production processes, innovation ecosystems, infrastructure, and costs (Rubio et al., 2020; The Good Food Institute, 2021).

Contrary to expectations, the entrepreneurial ecosystem and the availability of technologies that would enable the development of enhanced mechanisms for sustainable production and consumption in agriculture and alternative protein has not resulted in high adoption rates of circular economy principles in the organization of agri-food systems. This pattern does not differ from that observed in other industries. The Circularity Gap Report (2021) shows that the world was only 8.6 % circular by 2020 (Haigh et al., 2021). Therefore, it is imperative to understand the key variables influencing the development of the entrepreneurial ecosystem and innovation in alternative protein. To do so, we focus on Brazil, one of the world's largest economies and a food provider to approximately 20 % of the global population, with a rich bioeconomy to explore (CNI, 2020).

Compiled data from the FAO show that Brazil is the world's fourth largest grain producer—representing 7.8 % of global production—and the top beef exporter, accounting for 14.4 % of the market. Brazil also accounts for the second largest share of global grain exports, with >1.1 billion tons, representing 12.6 % of global exports (Embrapa, 2021). Between 2000 and 2020, Brazil exported 119 million tons of beef, pork, and chicken meat. These sales amounted to US$ 265 billion (Embrapa, 2021), helping to sustain agri-food systems that, just in the case of beef, employ approximately 4.5 million people directly or indirectly (ABIEC, 2020). This massively important economic sector in Brazil also imposes significant burdens on the environment. Livestock has been consistently ranked as the top driver of deforestation in the Brazilian Amazon, playing a critical role in biodiversity loss, climate change and land use management (dos Santos et al., 2021). If Brazil can capitalize on the benefits stemming from the alternative protein industry and overcome the barriers to circularizing its food chains, it can become a global innovator and exert significant influence on the development of key ingredients and technologies (Coslovsky, 2021; Machado et al., 2020; Rampasso et al., 2021), particularly connected to innovative products derived from the forest sector (Maximo et al., 2022), bioactive ingredients derived from food value chain inputs (Barbosa and de Carvalho Júnior, 2022) and the high potential of country's well-established sugarcane biorefineries to produce feed, bioenergy, food, pigments, fertilizers and bioactive compounds (Vandenberghe et al., 2022). Brazil is a uniquely positioned country that leads the transition towards CE-oriented food technologies, such as alternative proteins, and rethinks the technological foundation of one of its main economic sectors. There are clear co-benefits regarding employment, development, and environmental impact. Therefore, this study aimed to answer the following research question: *What are the enablers and barriers influencing alternative protein innovation in Brazilian companies*?

To answer this question, we conducted online semi-structured interviews with 18 experts from organizations operating in the alternative protein sector in Brazil. These interviews provided insights and perspectives on the enablers and barriers influencing the entrepreneurial ecosystem and innovation in the country. The companies engaged were startups, traditional companies (large food manufacturers), consultancies, and investment firms. Tax incentives, access to funding, opportunity costs, and human capital are critical factors driving innovation across the Brazilian alternative protein landscape. Public policies and tax incentives disproportionally benefits large, incumbent organizations in the meat industry, while high opportunity costs relative to investments in more established sectors and the long delays in securing the regulatory agencies' approval for new ingredients hamper steadier and voluminous flows of investment into the alternative protein industry. This study contributes to the literature on sustainable food systems and circular agri-food chains by systematizing barriers and enablers for alternative protein innovation in Brazil. This systematization can foster action to support the development of superior products and technologies in the most influential country in the agriculture sector.

2. Literature review

In the next two sections of the literature review, the main concepts that support this research will be presented, namely: (i) entrepreneurial ecosystems and innovation, and (ii) circular economy, alternative proteins and the bioeconomy.

2.1. Entrepreneurial ecosystems and innovation

Entrepreneurial ecosystem (EE) is defined by Cohen (2006) as an interconnected group of actors in a local geographic community oriented to sustainability innovation through the support and facilitation of new sustainable ventures. The key construct in an entrepreneurial ecosystem is that it is a system (Stephens et al., 2022) and the systemic conditions determine the success of the ecosystem. Definitions highlight the combination or interaction of elements that support entrepreneurial activity. Entrepreneurial ecosystem is defined as a set of interconnected elements that foster development and innovation (Isenberg, 2010). Policy, finance, markets, human capital, support, and culture are the key elements that interact, often through networks, producing shared cultural values that support entrepreneurial activity.

For each element, Isenberg (2011) proposes some sub-elements: policy (leadership, government), finance (financial capital), markets (early customers, networks), human capital (labor and educational

institutions), support (infrastructure, support professions), and culture (success stories, societal norms). The emphasis is on local and regional environments and the conditions required to generate and support ambitious entrepreneurship and innovation. Isenberg claims that each context requires its own ecosystem. This is because the elements of the system include several units and pieces that interact in different and distinctive ways. EE and innovation do not emerge in isolation rather in a very integrated and complex system with multiple elements and actors (Kansheba and Wald, 2020).

The framework and definition devised by Isenberg (2010, 2011) have inspired several studies (Acs et al., 2017; Kansheba and Wald, 2020; Khatami et al., 2021; Stephens et al., 2022). Positive entrepreneurial ecosystems and their effects on development can be illustrated by successful EE such as in London, Tel Aviv, Singapore, Silicon Valley, and Boston. These entrepreneurial ecosystems are characterized by having advanced financial service systems that facilitate access to venture capital, good infrastructures, technological innovation, investment in research and development activities through universities and serious government efforts to support entrepreneurial initiatives (Acs et al., 2017).

The extant literature has primarily produced long lists of elements that might matter equally to innovation (Stephens et al., 2022). However, it is not entirely clear empirically if some elements might be recognized as enablers or barriers to innovation, in each geography. Some studies such as the one of Khatami et al. (2021) investigates the entrepreneurial sustainable innovations (ESIs) that work against the five elements (policy, finance, human capital, support and culture) of the entrepreneurial ecosystem (EE) based on Isenbergs' model (Isenberg, 2011). By conducting empirical research on 14 European countries, the study addresses how an EE can support entrepreneurs in creating sustainable innovations. They show that ESIs are positively correlated with policy, finance, and support in terms of infrastructural and administrative support, whereas culture and human capital do not significantly influence ESIs. In addition, the country-level capability of ESIs is measured, showing that Ukraine, Romania, Poland and the Czech Republic demonstrate a low-level capability of ESIs, while Germany, the UK, Sweden, Netherlands, France and Belgium show a high-level capability.

One study of EE in Ireland provided an overview of the complex, multi-dimensional relationships that occur within the elements of the EE (Stephens et al., 2022). Key findings show that perceptions around policy support are significantly related with cultural strength and positive infrastructure. Perceptions around finance are positively and significantly related to policy importance, access & assistance to supports and business incubation. Finance and cultural strength are related to negative infrastructure. Enterprise & innovation are related to several factors such as access & assistance, success, academia, educational programs, personal development, and business networking. Support importance is related significantly to both access & assistance and business incubators. Success is significantly related to business incubators, personal development, and business networking. Academia is significantly related to business incubators, business networking and positive infrastructure. Educational programs are significantly related to personal development, business networking and positive infrastructure. Business networking and positive infrastructure are also significantly related.

In one of the latest developments in this field, Talmar et al. (2020) developed the Ecosystem Pie Model - like that of Isenberg (2011). They build on the insight that the operating logic of any given innovation ecosystem is dependent on the properties of the individual actors *as well as* the properties of the ecosystem network. They distinguished constructs and their relationships at the structural ecosystem level (EL) and the actor level (AL). One of the contributions of the proposed framework, in the context of the EE, is the consideration of interplay between its structural elements and actor level elements. Structural – ecosystem level (EL) is composed ecosystem's value proposition, user segments and actors. Within the Actor level (AL) they consider the resources, activities, value addition, value capture, dependence, and risk.

Both models, proposed by Isenberg (2011) and Talmar et al. (2020), were selected as the basis of the theoretical background of this research. Although they were not specific to alternative protein innovation determinants, both models can help managers to understand and make sense of ecosystems as complex entities with inter-related elements. We believe that by understanding the critical elements managers can take decisions that are likely to determine the success (or not) of innovation and the ecosystem.

2.2. Circular economy, alternative proteins and the bioeconomy

The CE has also emerged as a new business approach (Blomsma et al., 2019; Lopes de Sousa et al., 2018). It pursues the safeguard of planetary boundaries (Steffen and Stafford Smith, 2013), which is attained by increasing the share of renewable and recyclable resources, and the aggressive reduction of raw materials and energy consumption (EEA, 2016). To achieve the benefits associated with CE implementation, many companies actively engage in the transition to circularity (Homrich et al., 2018; Rodrigues et al., 2019; Tukker, 2015; Tura et al., 2019). This transition involves fundamental changes across different processes within the value chain, from product design and innovation to end-of-life mechanisms and business model development (De los Rios and Charnley, 2017; EEA, 2016). This transition process can be understood through the lenses of technological transitions (Geels, 2002; Geels et al., 2017).

Specifically, the progressive awareness of the importance of circularizing the meat industry and animal agriculture has produced different approaches. These can be found on the supply and demand sides of organizational and technological solutions. On the supply side, several technologies have been widely recognized as fundamental enablers of a new circular economy (Bressanelli et al., 2018; Pagoropoulos et al., 2017; Rajput and Singh, 2019; Rosa et al., 2020). On the demand side, targets related to sustainable practice adoption in agriculture, eating habits, and preferences can be seen in multilateral commitments and shifts in consumer demand. Moreover, emerging literature discusses the requisites for adopting circular economy principles in agri-food systems (Miranda et al., 2021).

Within this context, a wide set of technologies claim to be the key enablers of the sought-after sustainability transition in agri-food systems (FAIRR, 2022; Lavelli, 2021; Liaros, 2021). Technological aspects play a crucial role in establishing CE as a solid paradigm in the production and consumption processes. The development of technologies for the alternative protein industry largely depends on the source of the novel ingredient.

These sources are (1) plants, (2) animal cells, and (3) microbial cells. These novel ingredient sources go beyond protein production and constitute the core of a wide range of product categories, representing complex processes and value chains. Such product categories include (1) *plant-based products*, such as meat, eggs, and dairy; (2) *cultivated (or cultured) meat*; and (3) *precision fermentation* (The Good Food Institute, 2021; Grossmann and McClements, 2021; Reis et al., 2020).

Plant-based proteins have the highest dissemination across countries, industries, and consumers. These are made from plants or fungi and are chiefly designed to replace animal protein in recipes, food products, and ingredients. Cultivated meat refers to real animal tissue and meat produced by cultivating animal cells in specific substrates in controlled environments. Lastly, precision fermentation has recently become a viable technological a promising platform for the food industry. Precision fermentation refers to the cultivation of microbial organisms. The aim is to process foods and ingredients, obtain more of that organism, and develop other flavors, fats, and enzymes for plant-based or cultivated products, such as meat, dairy, and eggs (The Good Food Institute, 2021).

These alternative protein technologies are part of a larger landscape that has been widely recognized as the bioeconomy. The bioeconomy is a multi-stakeholder and multi-disciplinary concept that can be defined

as an economy that is anchored in transforming renewable biological resources into value-added products, including food, bio-inspired products and services, feedstock and bioenergy (Mak et al., 2020). The bioeconomy concept has advanced to incorporate the principles of the CE in the so-called "circular bioeconomy", whose main tenets stand on minimizing the use of virgin resources and promoting cascaded uses to add value to products and services (Maina et al., 2017; Salvador et al., 2021; Stegmann et al., 2020).

A successful circular bioeconomy depends on the consistent engagement of different key stakeholders, ranging from academics and policymakers to economists, engineers, lawyers and consumers (Maina et al., 2017). When bioeconomy efforts are carried out in specific geographies and regions, social, environmental and economic performance varies significantly (D'Adamo et al., 2022; Wreford et al., 2019). Therefore, the adequate integration and management of industrial and agricultural stakeholders become critical (Stegmann et al., 2020; Van Lancker et al., 2016). That highlights the fundamental role that primary sectors play in the circular bioeconomy.

Many governments have resorted to circular bioeconomy as a strong overarching strategy to tackle the climate change potential, dependency on fossil fuels and other environmental impacts of the primary sectors, such as agriculture, forestry, fisheries, etc. (Wei et al., 2022; Van Lancker et al., 2016). The productive inclusion of these sectors, however, is challenging. Primary sectors of the economy can be integrated into the circular bioeconomy through resource-efficient technologies, involvement in local supply chains and bio-based solutions, development of management practices focused on ecosystems, and standards and certifications for distinguished suppliers and countries relative to their superior social and environmental performance (Park and Grundmann, 2022).

These standards and certifications foster transparency across different value chains and industrial sectors, assuring the consistent development of products and offerings against sustainability and circularity goals and criteria while protecting against a self-referential attitude that might lead to greenwashing and other distortions. In turn, this consistent pursuit of more circular enables an organizational transition that allow consumers at large to accept higher prices as renewable resources and circular strategies (e.g., reuse, recycle, recovery, bio-based materials) are adopted (Appolloni et al., 2022). This transition is clear in motion within the alternative protein sectors both globally and nationally.

3. Research methodology

While Brazil is a uniquely positioned country that has led to the transition towards CE-oriented food technologies, alternative protein innovation is still a recent trend in the market. Few studies have investigated this phenomenon. Thus, a qualitative exploratory research methodology was chosen to fulfill the research objectives due to its suitability for exploratory research (Hair et al., 2010; Creswell, 2009). In addition, this approach enables the thorough collation of knowledge and insights from experts (Eisenhardt and Graebner, 2007) on the enablers and barriers influencing alternative protein innovation. Fig. 1 illustrates the research methodology.

The first stage of the research was a non-systematic desktop review of relevant literature (Fig. 1 - Step 1) from journal articles, conference papers, research reports, and internet searches. The goal was to understand state-of-the-art alternative protein innovation technologies and identify key innovation determinants. As a result, a systematized set of enablers and barriers to innovation (Table 1) was

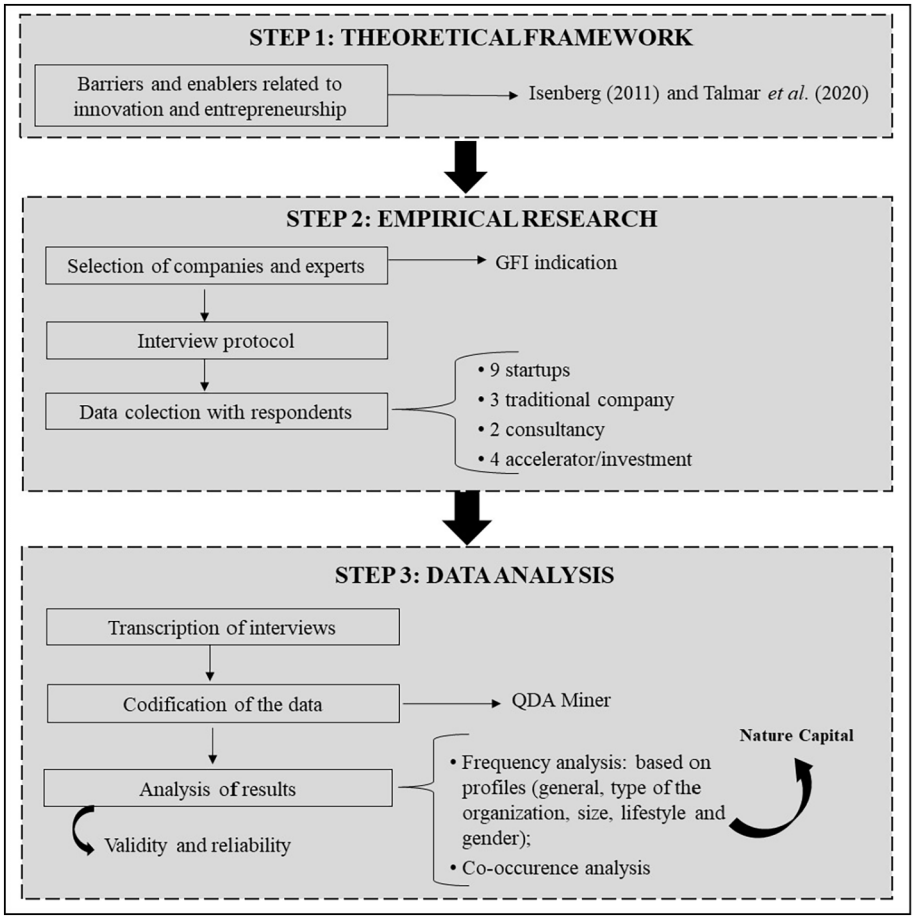

Fig. 1. Research methodology.

Table 1
Systematized set of enablers and barriers to innovation.
Source: Adapted from Isenberg (2011) and Talmar et al. (2020).

Enablers and barriers	Description
Culture	Brazilian culture in relation to innovation and entrepreneurship, consumption and acceptance of alternative proteins, creating something healthy.
Finance	Access to private investments, venture capital funds, internal financial structure. Supplies cost. Opportunity cost for the Brazilian market.
Human capital	Soft and hard skills of the entrepreneur and those who work around them.
Innovation and research infrastructure	Access to technologies, equipment, laboratories, ingredients. Knowledge and access to public, private, Brazilian and foreign research institutes and universities.
Internal innovation management/Internal governance	Essential activities within the company that convert resources into value, through a process of coordination and internal (between functional areas of the company) and external (sector) integration. Access to supplies.
Market	Profile of competitors and consumers (creation of something healthy), vision of market trends/consumption in alternative protein.
Political and legal aspects	Financial investment, legislation, fiscal and tax benefits. Opportunity cost for the Brazilian market.
Social capital	Partnerships, distribution channels and shared logistics, entrepreneurship network.

developed as the foundation for preparing the interview protocol (Denzin and Lincoln, 1994; Brinkmann, 2007).

Two primary articles by Isenberg (2011) and Talmar et al. (2020) were selected as the basis of the theoretical background of this research. These authors address Entrepreneurs Ecosystem elements that can be enablers and barriers of innovation, as discussed in the literature review section.

In Step 2 (Fig. 1), organizations and experts were selected for the interview process, following a purposeful sampling procedure. This selection enabled a choice of information-rich individuals for in-depth investigation, contributing to the reliability and validity of the research (Liamputtong and Ezzy, 2005; Creswell and Clark, 2017). Expert knowledge, or elicitation, is a structured and transparent method for approaching experts on a subject lacking information. It seeks to make explicit published and unpublished expertise. It can serve as a means to synthesize the limited available knowledge before conclusive scientific evidence becomes available. The quality of knowledge derived from experts, or at least its transparency and reproducibility, improves when expert elicitation is applied using a systematic protocol (Kandlikar et al., 2007; Morgan et al., 2001; Morgan and Keith, 1995).

Organizations were identified through a review of their existing relationship with the Good Food Institute—a global non-profit organization devoted to promoting alternative proteins with offices in Brazil. Companies were selected based on their leadership in their respective sectors. Therefore, the companies represented in this sample are the most experienced organizations in their respective fields. The Good Food Institute facilitated a connection with each potential respondent, contacted by phone or e-mail. When contacted, the researchers explained the research objectives to the potential interviewees and asked them about their willingness to participate in the interviews. The interviewees were selected based on (1) their extensive experience in the alternative protein market, (2) their availability to contribute to the research, and (3) their seniority and strategic positions within the organizations they represent. We emphasized roles such as founders, CEOs, senior directors, and heads of business units.

Ultimately, 22 companies were contacted, and 22 experts were appointed based on the criteria suggested. Four experts declined or could not make an appointment, resulting in 18 respondents for our sample. Detailed information regarding the expert profiles is provided in Table 2. The relatively limited number of interviewees reflects the size of the alternative protein market in Brazil, which is still in its infancy, but has incredible potential for growth. According to Euromonitor data, Brazil's market for plant-based meat and seafood reached US$107 million in sales in 2021, compared to US$82 million in 2020, which entails approximately 30 % growth (Euromonitor, 2021). Analysts forecast that the alternative protein sector will exceed US$ 425.3 million in sales in the Brazilian market by 2026.

Based on these factors, we feel that the number of interviewees is sufficient, as the information collected can provide adequate data to reach meaningful and insightful conclusions. This can ultimately satisfy the sampling criteria – reaching theoretical saturation – commonly accepted in qualitative research (Marshall et al., 2013). Despite using different approaches to assess saturation, Hennink and Kaiser (2021) argued that studies reach saturation within a narrow range of interviews. As for the sample size, they identified that an average of 12–13 interviews across all tests reached saturation.

The interview protocol was developed and reviewed by all the authors. It consisted of open-ended questions formulated and based on a theoretical framework. Supplementary material presents the interview protocol. The first two interviews were conducted with experts and functioned as a pretest. Following the pretest, the protocol questions were maintained for startups but were adapted for interviews with experts from traditional companies. These interviews were retained for analysis. Pretesting the research protocol helps evaluate and adjust the instrument to improve its reliability and validity.

One of the authors conducted 18 online semi-structured interviews to provide insights and perspectives from experts on alternative protein innovation in Brazil. The decision for the online format of the interviews

Table 2
Expert profiles.

Code	Type of product	Job position	Time in company (in years)
Startups			
S1	Meat and dairy products	Founder and CEO	>2
S2	Dairy products	Founder and CEO	>3
S3	Dairy products	Founder and CEO	>4
S4	Beef and dairy products	Operations and innovation manager	>9
S5	Egg	R&D manager	>2
S6	Mayo, beef and breaded prod	Founder and CEO	>5
S7	Egg	Founder and CEO	>1
S8	Milk	Founder and CEO	>7
Traditional company			
T1	Meat	Plant business unit head	>5
T2	Milk	Head of business	>6
T3	Ingredients	Marketing management	>5
T4	Ingredients	Founder and director	>6
Consultancy			
C1	Innovation	Founder and CEO	>10
C2	Innovation	Co-Founder and partner	>5
Investment firms			
A1	Investor	Founder	>2
A2	Investor	Partner	>3
A3	Investor	Founder and CEO	>1
A4	Investor	Co-Founder and partner	>6

(pretesting and actual) using Google Meet was made due to the COVID-19 pandemic. Besides pretesting, the participants had a chance to comment on additional items and clarify aspects of the points they made during the interviews to improve the validity and reliability of the research (Creswell, 2009; Alshenqeeti, 2014).

The interviews lasted between 20 and 40 min and were conducted from October to December 2021. The interviews were recorded. Ethical approval was obtained before the start of the study. Furthermore, the experts were informed of the procedure and gave informed consent to participate before beginning the interview. Personal anonymity was ensured for all participants, as the experts were not participating as individuals but rather represented their organizational context.

In terms of saturation, each interview had a unique perspective. However, after interviewing the 18 experts, most viewpoints had common themes. Thus, we decided not to recruit and interview more experts, in line with Hennink and Kaiser's (2021) conclusions on data saturation. It is important to note that, although experts may differ in the extent of their expertise on some of the topics discussed, we treated and weighed all expert contributions equally in the analysis.

The records were transcribed verbatim and coded. The content was further analyzed using the QDA Miner™ software (Fig. 1 – step 3). Deductive content analysis can be used to analyze data derived from documents or open-ended surveys using a framework based on a previous theory, even if the theory was tested in a different context, situation, or period (Vaismoradi et al., 2013). It can offer systematic and objective means to make inferences from data and to describe and quantify specific phenomena with minimal information loss (Krippendorff, 2013). We approached the data within the scope of frequency and co-occurrence based on the categories of themes in systematic coding.

The enablers and barriers to innovation include categories on political and legal aspects, finance, social capital, innovation and research infrastructure, culture, market, internal innovation management/internal governance, and human capital. To that end, the QDA Miner™ enabled frequency analysis to identify the main barriers and enablers of innovation of alternative proteins. This analysis was based on identifying the respondents' general profile, type of organization (startup, traditional company, consultancy, and investment firms), size, and lifestyle (based on their diet). In addition, co-occurrence analysis allowed the verification of simultaneous code presence, regardless of their order of appearance in the transcription document. This was done by examining the proximity of the codes throughout the text, allowing an understanding of which enablers are most often associated with barriers (QDA, 2017). The coefficient of co-occurrence used was the Jaccard index, which gives equal weight to cases where co-occurrence is identified (a) and cases where one item is found (b) but not the other (c). Thus, it was calculated as $a / (a + b + c)$ (QDA, 2017).

This study identified the main enablers and barriers to alternative protein innovation in the Brazilian market based on qualitative data analysis.

4. Results

In this section, the results will be presented. The tables show the frequencies that barriers and enablers (E) appear according to the general profile of the interviewees, type and size of the company, and lifestyle of the interviewees. Table 3 presents all the sample respondents.

The most important barriers to alternative protein innovation are *political and legal aspects* and *finance.* Regarding *political and legal aspects*, the interviewees often cited the lack of Brazilian tax incentives for alternative proteins as a barrier to innovation. The taxes to sell plant-based beverages in Brazil are much higher than those for selling milk-based beverages. A positive development is that Brazil recently approved legislation that created a specific classification for plant-based beverages, zeroing their tax rates. Previously, all plant-based beverages were classified only as "other beverages."

Table 3
General frequency of barriers and enablers.

Category	Code	Cases	% cases
Barriers	Political and legal aspects	16	88.90 %
	Finance	16	88.90 %
	Social capital	13	72.20 %
	Innovation and research infrastructure	13	72.20 %
	Culture	12	66.70 %
	Market	12	66.70 %
	Internal innovation management/internal governance	11	61.10 %
	Human capital	9	50.00 %
Enablers	(E) Human capital	17	94.40 %
	(E) Internal innovation management/internal governance	16	88.90 %
	(E) Culture	15	83.30 %
	(E) Political and legal aspects	14	77.80 %
	(E) Finance	11	61.10 %
	(E) Market	10	55.60 %
	(E) Innovation and research infrastructure	10	55.60 %
	(E) Social capital	5	27.80 %
	(E) Nature capital	1	5.60 %

"*I think investment in the sector is a problem. When looking at venture capital in Brazil, nobody has an appetite to invest. This is the opposite of the situation in the United States.*"

[Interviewee S6]

From the *finance* aspect, access to funding and the Brazilian opportunity cost appeared to be highly important to respondents. Funding is essential to developing new and better products, and scaling is critical in making them more affordable. However, Brazil lacks specific funding for innovation in alternative proteins. In terms of opportunity cost, Brazil's bureaucracy slows the process of innovation. For instance, authorization from the National Sanitary Surveillance Agency (ANVISA) to use alternative ingredients can take up to two years.

The interviewees cited *social capital* and *innovation and research infrastructure* with the same frequency as barriers. There is a consensus on the need to develop trusted partnerships among the players in the alternative protein sector, including stakeholders such as research institutes and ingredient and equipment producers. More particularly, ingredient and equipment producers are critical stakeholders because almost all of the equipment used in Brazil is imported from foreign markets, increasing production costs and the price of end products in the Brazilian market.

"*(...) are afraid of getting information from the other, sometimes causing a lot of relationship problems, relationships are the most complicated (...) of being harmed in some way by trusting people*".

[Interviewee C2]

"*Packaging infrastructure, process, final product, ingredient is the biggest difficulty. Physical infrastructure, a factory, is one of the biggest bottlenecks because it is expensive, and in Brazil, it is difficult to find one for rent.*"

[Interviewee A1]

Human capital and *internal innovation management/internal governance* were the least frequent barriers. In contrast, they were highlighted more frequently as enablers of alternative protein innovation. The workforce in this sector are motivated, as the interviewees said that they do not have problems hiring specialized labor (in the technical aspect). In addition, *human capital* is highlighted as a professional who understands the AP sector and consumer motivations for consuming these products (soft skills). In terms of *internal innovation*, the essential and strategic activities of the analyzed companies can generate innovation, whether in products or processes. The challenge is not the internal governance needed to innovate, but external aspects such as legislation, financing, and opportunity cost. *Culture* was also identified as an

enabler, demonstrating that there is space and acceptance of Brazilian consumers for the consumption of alternative proteins.

> "*We have in Brazil, in addition to a wide variety of everything, we have knowledge and an entrepreneurial streak precisely to not limit ourselves and explore everything that this area or the country can promote. So, this is a facilitator in this plant-based area in Brazil*".
>
> [Interviewee A2]

When considering the four types of organizations within the sample (startups, traditional industries, consultancy, and investment firms), there are different perceptions about the barriers and enablers of alternative protein innovation presented Table 4.

Almost all types of organizations highlighted *finance* as a barrier in Table 4; however, it is less important for traditional companies. Financial buying power of traditional companies improves their access to technology, equipment, and ingredients, enabling innovation. This is not the same for startups, which require well-developed social capital or the support of an investment fund to innovate. *Social capital* is also a frequent barrier, especially for startups and investment firms (reflecting their view of the sector). This is because the innovation ecosystem of this sector is still recent in Brazil. The social capital network, especially with startups is leveraged to buy raw materials together; however, it is less frequent for sharing technology, for an example.

> "*We talked to some startups that escaped from thematic co-workings because they were afraid of stealing revenue, sharing sensitive information. So, I see a lot of collaboration in getting raw materials together, and when one makes a good capture, it's good for everyone, but when it comes to sharing laboratory, technology, and intelligence, it's the opposite.*"
>
> [Interviewee A4]

Secondly, traditional companies, consultants, and investment firms pointed out *market* as a barrier, due to a consumer bias towards alternative protein products. This association would be biased towards the ultra-processed aspects of alternative protein products, representing one of the sector's greatest challenges in transforming alternative protein products into healthy and desirable products.

Finally, while *political and legal aspects* are frequent barriers for startups, traditional companies do not perceive them the same way. This can be explained by their financial and lobbying power, which startups do not have. The opposite happens with *culture,* because startups, tend to be closer to their final consumers and, thus, can communicate and educate them more effectively than traditional companies. Although highlighted as barriers, *social capital* and *market* are also perceived as enablers. There is a general lack of in-depth market knowledge about alternative protein consumption and inefficiencies in partnerships in terms of information sharing, technology, and logistics. If improved, these could become critical innovation enablers. Investment firms often indicated *natural capital* as enabler because Brazil is rich in natural resources and has favorable soil and climate conditions for alternative protein innovation.

> "*Brazil has a wealth of biodiversity, of grains, of nuts, in the exceptional Cerrado. The Amazon Forest was impressive. It is a differential of Brazil, and we have to be a little careful to build an economy that is a little more circular, regenerative.*"
>
> [Interviewee A4]

In Table 5, it is worth mentioning that *finance* is a barrier for all company sizes, justified by the cost of imports and the exchange rate. *Culture* as a barrier, demonstrating difficulty by medium and large companies in dealing with issues related to alternative proteins in Brazil, mainly because alternative protein is not the main market of these companies. On the contrary, it is a new and unknown market segment.

> "*Consumers have high expectations of finding a plant-based product that replicates exactly the same experience as the animal. That is the main barrier today.*"
>
> [Interviewee T1]

Market and *social capital* appear to be more of a barrier for startups, highlighting their challenges in establishing partnerships to distribute their products in large retail stores. On the other hand, social capital appears as the primary enabler for companies of all sizes, demonstrating that an entrepreneurship network and partnerships (mainly for distribution) are useful to drive alternative protein innovations, especially for small companies that do not have the same market penetration as large companies.

> "*Who will have shelf space? The big ones who can afford it. So, if you want to go to the market, you'll have to have a structure the same way they do. The small ones can't do it*"
>
> [Interviewee C2]

It is worth mentioning *human capital* as an enabler because startups and medium-sized companies depend more on entrepreneurial skills than large companies. The team work is essential, requiring technically trained people and the interest and alignment of the founders. These are

Table 4
Frequency of barriers and enablers (type of organization).

Codes	Startup	Traditional company	Consultancy	Investment firms
Internal innovation management/internal governance	9	3	5	6
Human capital	4	1	1	6
Culture	7	11	2	8
Political and legal aspects	18	5	1	10
Finance	20	6	11	12
Market	6	9	10	10
Social capital	12	2	5	14
Innovation and research infrastructure	10	7	0	9
(E) Internal innovation management/internal governance	14	11	4	6
(E) Human capital	19	2	2	7
(E) Culture	9	3	0	5
(E) Political and legal aspects	0	0	0	1
(E) Finance	5	1	0	1
(E) Market	8	8	7	7
(E) Innovation and research infrastructure	12	4	2	5
(E) Social capital	27	10	8	3
(E) Nature capital	4	2	1	8

Table 5
Company size frequency of barriers and enablers.

	Small	Medium	Large
Internal innovation management/internal governance	14	4	5
Human capital	9	2	1
Culture	11	7	10
Political and legal aspects	15	12	7
Finance	27	14	8
Market	21	6	8
Social capital	27	3	3
Innovation and research infrastructure	11	7	8
(E) Internal innovation management/internal governance	10	14	11
(E) Human capital	10	18	2
(E) Culture	7	4	6
(E) Political and legal aspects	1	0	0
(E) Finance	1	3	3
(E) Market	16	5	9
(E) Innovation and research infrastructure	7	8	8
(E) Social capital	16	18	14
(E) Nature capital	10	4	1

the aspects that the investors we interviewed considered when assessing business potential for investments. Another enabler highlighted by the startups was *natural capital*. In this case, the innovation capacity is linked to the ingredients related to Brazilian biodiversity. Entrepreneurs' skills to innovate in alternative proteins go beyond the ingredients available in the market and can be positively influenced by the innovation potential of local biodiversity.

Regarding lifestyle (Table 6), the primary barrier for vegan consumers is related to the *cultural* aspects of the Brazilian population, while for non-vegans it is *finance*. The higher the level of consumer awareness related to consumption of protein, the lower the barriers related to price, for example, a sensitive aspect of the financial barrier.

5. Discussion

Fig. 2 highlights the central relationships between the enablers and barriers, separated by the internal and external context of the companies.

One of the key results is that the central relationships refer to aspects outside the organizational operation. Some barriers, like *finance* and *innovation and research infrastructure,* depend on internal operations such as a stable financial condition or a company's technological infrastructure. However, they also depend on external factors for their success, like the country's economic situation. Some investment firms pointed out that the alternative protein ecosystem in Brazil is embryonic and fragmented, which highlights that external factors are prevalent.

Isenberg (2010) claims in your study that each context requires its own ecosystem, because the elements of the system interact in different and distinctive ways. As pointed out by Stephens et al. (2022) the perceptions around finance are positively related to policy importance. The Brazilian economic situation does not stimulate the development of the sector, especially regarding specific funding for alternative protein innovation. Some companies, in order to complete their innovation process, need to send their products abroad to access technology, while other companies prefer to export their products due to the more attractive exchange rate. Acs et al. (2017) highlight that financial support can facilitate access to venture capital, good infrastructure and technological innovation, aspects that may be useful to support Brazilian entrepreneurial initiatives.

Brazilian *culture* has been indicated as an enabler of innovation. The use of alternative proteins as a way of circularizing the meat and animal agriculture is highlighted in the literature (Bressanelli et al., 2018; Pagoropoulos et al., 2017; Rajput and Singh, 2019), in which eating habits, and preferences can be seen as a smart shifts in consumer demand and cultural aspects. The results of this research show that, conscious consumers or those following a vegan/vegetarian diet tend to recognize the value of such products, regardless of price. On the other hand, price is a relevant attribute for non-vegan consumers. Appolloni et al. (2022) point out in their research that the consistent pursuit of a more circular economy provides a transition that allow consumers at large to accept higher prices as circular strategies are adopted. This shows that consumer awareness needs to be raised as it influences the search for healthier and more sustainable food. Furthermore, cultural beliefs can be used strategically to increase the consumption of alternative proteins in line with a successful transition to bioeconomy (Mak et al., 2020; Stegmann et al., 2020). Salvador et al. (2021) also found that a culture that is open to change, adaptation, and innovation can be beneficial to a circular bioeconomy, as is the case in Brazil.

Therefore, further investment in consumer education – especially in line with bioeconomy principles – might be necessary to increase the consumption of alternative protein products and thus, innovation. Some respondents highlighted that consumer education and police support would improve Brazil's innovation ecosystem in alternative proteins. As in Stephens et al. (2022) study, the perceptions around policy support are significantly related with cultural strength and positive infrastructure.

Considering the company's organizational structure, *human capital* and *internal innovation management/internal governance* are the main barriers to innovation in alternative protein. *Social capital*, *culture* and *finance* are the main enablers that help dealing with those barriers. *Human capital* was highlighted as a positive aspect for innovation, both for technical and soft skills. In many sustainability-oriented food industries, human capital represents a key factor for competitive advantage. The ability of managers to work with strategic players across the value chain to devise initiatives in alternative protein innovation proves to be an advantage to innovate in this sector. The engagement with critical stakeholders, such as the raw material suppliers, packaging and technology providers, and distributors, enables better positioning of innovative products and swifter go-to-market strategies. For instance, if companies can build strong, long-term relationships with logistics providers and retail operators, reaching essential supermarket shelves becomes easier. However, as noted in Isenberg (2011)'s study, the existence of talented people to try out promising ideas in the marketplace does not lead to innovation if they lack the (financial) resources. This is why the *finance* aspect is an enabler for alternative protein innovation. Likewise, partnerships (social capital) can improve people's skills and drive innovation. So, the intensity of managers´ involvement reflects the degree of existing partnership that the company can use in the social capital.

Social capital appears to be an enabler at almost all relationship levels and help to overcome some barriers through sharing resources, improving partnerships, and expanding the entrepreneur network within the alternative protein sector. As presented in Salvador et al. (2021), partnerships with research institutions might enable more efficient research

Table 6
Lifestyle frequency of barriers and enablers.

	Vegan	Flexitarian	Vegetarian	Eat fish	Meat-eaters	Did not inform
Internal innovation management/internal governance	7	6	6	0	3	1
Human capital	3	5	1	0	2	1
Culture	12	9	3	1	3	0
Political and legal aspects	8	13	1	2	6	4
Finance	10	13	11	4	8	3
Market	7	14	4	1	8	1
Social capital	12	10	5	0	5	1
Innovation and research infrastructure	11	7	1	1	3	3
(E) Internal innovation management/internal governance	11	12	4	1	2	5
(E) Human capital	15	3	1	5	3	3
(E) Culture	4	10	0	0	2	1
(E) Political and legal aspects	0	0	0	0	1	0
(E) Finance	0	6	0	0	0	1
(E) Market	6	14	5	2	3	0
(E) Innovation and research infrastructure	0	8	4	3	4	4
(E) Social capital	19	15	7	3	1	3
(E) Nature capital	7	2	0	1	4	1

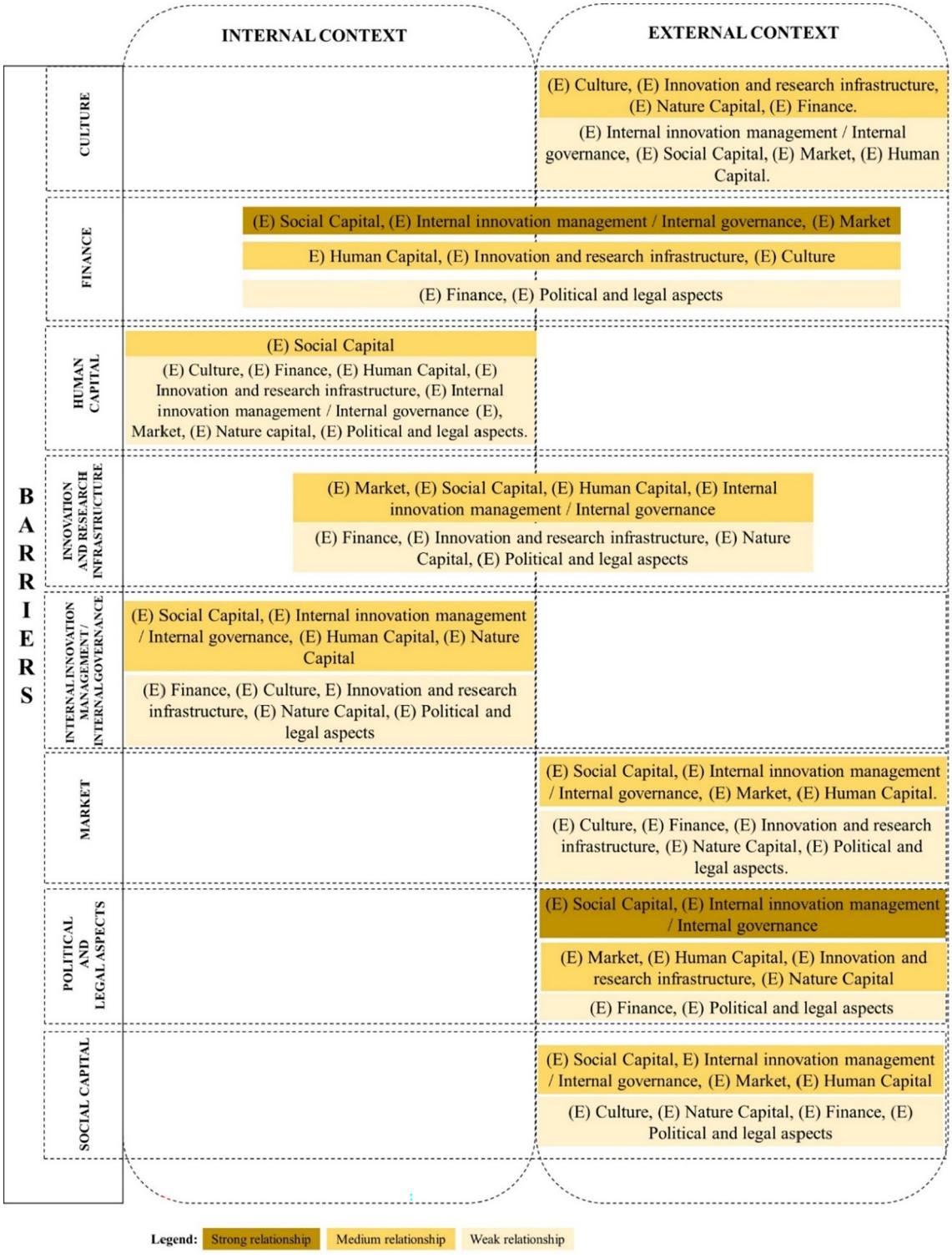

Fig. 2. Enablers and barriers influencing alternative protein innovation in Brazilian companies.

and development, besides allowing highly-skilled intellectual workforce into the organization. This could be useful to develop new ingredients, exploring the potential of Brazilian biodiversity (*natural capital*). Taking advantage of partnerships, to explore local biodiversity, is in line with Maina et al. (2017) and Stegmann et al. (2020) studies, in which they argue that for a circular bioeconomy to thrive it is essential to have the commitment of different key stakeholders, such as academics and policymakers, economists, the government and consumers.

The adequate integration and management of industrial and agricultural stakeholders become critical to social, environmental and economic performance (Stegmann et al., 2020; Van Lancker et al., 2016). The development of the entrepreneurial ecosystem and innovation in the alternative protein sector in Brazil, focused on circular bioeconomy, depends on strategic partnerships. Special attention to partnerships with the research institutes, and with the suppliers of ingredients and equipment. Finally, in line with Isenberg's study (2011), there is a

need to strengthen policy, markets, capital, human skills, culture, and support (financial and supply).

As with all empirical research, this study has some limitations. First, the empirical data was collected in Brazil, with a concentration of companies operating in the most developed regions of the country (south-eastern states), which are considered key financial and corporate centers. Although many of the insights might be applicable to other regions of Brazil and the world, some might still be limited to specific contextual circumstances. Second, this research did not capture different points of view within the same company. Only one person was interviewed per company, therefore the responses might carry their own bias towards the business and the sector. Third, the three different types of stakeholders were not homogenously represented in the number of respondents. There was a larger number of startups represented in the sample relative to the number of traditional companies, consultancies or investments firms interviewed. These limitations might be turned into future research opportunities to design similar studies in different geographies, collect large-scale, quantitative data using the insights of our interviews and exploring other sources of information within different companies operating in this sector.

6. Conclusions

This study brings a novel identification of the primary enablers and barriers influencing alternative protein innovation in Brazil. Regarding barriers, the lack of Brazilian tax incentives for alternative proteins is a major impediment to innovation. This is particularly true of startups, as they do not have the same financial or lobbying capabilities as traditional (larger) companies. Finance aspects such as access to funding and the Brazilian opportunity cost appeared to be important barriers. These factors are essential to developing a new, better, and affordable product. Scaling up is critical to product affordability.

Human capital, especially soft skills, is an essential facilitator of innovation. Specific knowledge of the sector and consumer motivations for buying alternative protein can leverage innovation performance. Innovative strategies may lose much of their value without that specific knowledge because they may not meet consumer needs, motivations, and desires. Social capital is also essential for building partnerships through the deliberate and informed development of an entrepreneurial ecosystem.

Natural capital is a vital enabler for innovation as Brazil is rich in natural resources and benefits from favorable soil and climate conditions. Such conditions are essential for alternative protein innovation. Together with entrepreneur skills, growing acceptance, and larger consumption of alternative proteins in Brazil, innovative capacity is linked to the ingredients related to Brazilian biodiversity. Competitive advantage based on the use of local biodiversity must consider the aspects of a circular and regenerative bioeconomy.

This study contributes to the literature on sustainable food systems and circular agri-food chains by providing an in-depth account of the barriers and enablers of innovation in the alternative protein sector. The insights can inform the development of policies and incentive mechanisms to foster innovation and increase quality product and technology availability. This is particularly important in the Brazilian context, as Brazil is one of the largest producers and exporters of agricultural products and mainstream protein.

Regarding practitioners, this study sheds light on an overlooked issue in the sector. Without knowledge of the main barriers and enablers to innovation, organizations have little room for experimenting with potential responses to enhance further development. Many of the barriers and enablers identified take the form of a public problem what demands that organizations in the sector should develop a common and shared understanding on how to support public policy improvements to foster alternative protein innovation. This study can help policymakers by clarifying the most sensitive and urgent topics requiring action.

Future research should focus on: (i) collecting and analyzing quantitative data via large-sample surveys to capture the perceptions and sector characteristics in Brazil; (ii) replicating the interview protocol in different developing and developed countries to account for national effects, along with similarities and differences in innovation patterns and trajectories; and (iii) investigating the role of technological and sustainable transitions for barriers and enablers in different locations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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References

ABIEC, 2020. Empregos, salários e impacto social da carne bovina – ABIEC. http://abiec.com.br/artigo-empregos-salarios-e-impacto-social-da-carne-bovina/ (Accessed June 2022).

Acs, Z.J., Stam, E., Audretsch, D.B., O'Connor, A., 2017. The lineages of the entrepreneurial ecosystem approach. Small Bus. Econ. 49 (1), 1–10.

Adams, K.T., Osmani, M., Thorpe, T., Thornback, J., 2017. Circular economy in construction: current awareness, challenges and enablers. Proc. Inst. Civ. Eng. Waste Resour. Manag. 170 (1), 15–24. https://doi.org/10.1680/jwarm.16.00011.

Akbarian, A., Andooz, A., Kowsari, E., Ramakrishna, S., Asgari, S., Cheshmeh, Z.A., 2022. Challenges and opportunities of lignocellulosic biomass gasification in the path of circular bioeconomy. Bioresour. Technol. 127774.

Ali, S.S., Elsamahy, T., Abdelkarim, E.A., Al-Tohamy, R., Kornaros, M., Ruiz, H.A., Sun, J., 2022. Biowastes for biodegradable bioplastics production and end-of-life scenarios in circular bioeconomy and biorefinery concept. Bioresour. Technol. 127869.

Alshenqeeti, H., 2014. Interviewing as a data collection method: a critical review. Engl. Linguist. Res. 3 (1), 39–45.

Appolloni, A., Chiappetta Jabbour, C.J., D'Adamo, I., Gastaldi, M., Settembre-Blundo, D., 2022. Green recovery in the mature manufacturing industry: the role of the green-circular premium and sustainability certification in innovative efforts. Ecol. Econ. 193. https://doi.org/10.1016/j.ecolecon.2021.107311.

Barbosa, J.R., de Carvalho Júnior, R.N., 2022. Food sustainability trends-how to value the açaí production chain for the development of food inputs from its main bioactive ingredients? Trends Food Sci. Technol. 124, 86–95.

Blomsma, F., Brennan, G., 2017. The emergence of circular economy: a new framing around prolonging resource productivity. J. Ind. Ecol. 21 (3), 603–614. https://doi.org/10.1111/jiec.12603.

Blomsma, F., Pieroni, M., Kravchenko, M., Pigosso, D.C.A., Hildenbrand, J., Kristinsdottir, A.R., Kristoffersen, E., Shabazi, S., Nielsen, K.D., Jönbrink, A.K., Li, J., Wiik, C., McAloone, T.C., 2019. Developing a circular strategies framework for manufacturing companies to support circular economy-oriented innovation. J. Clean. Prod. 241. https://doi.org/10.1016/j.jclepro.2019.118271.

Bressanelli, G., Adrodegari, F., Perona, M., Saccani, N., 2018. Exploring how usage-focused business models enable circular economy through digital technologies. Sustainability (Switzerland) 10 (3). https://doi.org/10.3390/su10030639.

Brinkmann, S., 2007. Could interviews be epistemic? An alternative to qualitative opinion-polling. Qual. Inq. 13, 1116–1138.

Bryant, C.J., van der Weele, C., 2021. The farmers' dilemma: meat, means, and morality. Appetite 167, 105605. https://doi.org/10.1016/J.APPET.2021.105605.

CNI, 2020. Bioeconomia e a Indústria Brasileira. https://www.portaldaindustria.com.br/publicacoes/2020/10/bioeconomia-e-industria-brasileira/ (Accessed May 2022).

Cohen, B., 2006. Sustainable valley entrepreneurial ecosystems. Bus. Strateg. Environ. 15 (1), 1–14.

Cosenz, F., Rodrigues, V.P., Rosati, F., 2020. Dynamic business modeling for sustainability: exploring a system dynamics perspective to develop sustainable business models. Bus. Strateg. Environ. 651–664. https://doi.org/10.1002/bse.2395 February.

Coslovsky, S., 2021. Oportunidades Para Exportação de produtos Compatíveis com a Floresta na Amazônia Brasileira. https://amazonia2030.org.br/wp-content/uploads/2021/04/AMZ2030-Oportunidades-para-Exportacao-de-Produtos-Compativeis-com-a-Floresta-na-Amazonia-Brasileira-1-2.pdf (Accessed July 2022).

Creswell, J.W., 2009. Mapping the field of mixed methods research. J. Mixed Methods Res. 3 (2), 95–108.
Creswell, J.W., Clark, V.L.P., 2017. Designing and Conducting Mixed Methods Research. SAGE Publications.
D'Adamo, I., Falcone, P.M., Imbert, E., Morone, P., 2022. Exploring regional transitions to the bioeconomy using a socio-economic indicator: the case of Italy. Econ. Polit. 39 (3), 989–1021. https://doi.org/10.1007/s40888-020-00206-4.
De los Rios, I.C., Charnley, F.J.S., 2017. Skills and capabilities for a sustainable and circular economy: the changing role of design. J. Clean. Prod. 160, 109–122. https://doi.org/10.1016/j.jclepro.2016.10.130.
de Sousa, Lopes, Jabbour, A.B., Jabbour, C.J.C., Godinho Filho, M., Roubaud, D., 2018. Industry 4.0 and the circular economy: a proposed research agenda and original roadmap for sustainable operations. Ann. Oper. Res. 270 (1–2), 273–286. https://doi.org/10.1007/s10479-018-2772-8.
Denzin, N.K., Lincoln, Y.S., 1994. Handbook of Qualitative Research. (1st Ed.). SAGE.
dos Santos, A.M., da Silva, C.F.A., de Almeida Junior, P.M., Rudke, A.P., de Melo, S.N., 2021. Deforestation drivers in the brazilian Amazon: assessing new spatial predictors. J. Environ. Manag. 294, 113020. https://doi.org/10.1016/J.JENVMAN.2021.113020.
EEA, 2016. Circular economy in Europe: developing the knowledge base. https://www.eea.europa.eu/publications/circular-economy-in-europe.
Eisenhardt, K.M., Graebner, M.E., 2007. Theory building from cases: opportunities and challenges. Acad. Manag. J. 50 (1), 25–32. https://doi.org/10.5465/amj. 2007.24160888.
Ekmekcioglu, C., Wallner, P., Kundi, M., Weisz, U., Haas, W., Hutter, H.P., 2018. Red meat, diseases, and healthy alternatives: a critical review. Crit. Rev. Food Sci. Nutr. 58 (2), 247–261. https://doi.org/10.1080/10408398.2016.1158148.
Embrapa, 2021. Brazil is the world's fourth largest grain producer and top beef exporter, study shows. https://www.embrapa.br/en/busca-de-noticias/-/noticia/62619259/brazil-is-the-worlds-fourth-largest-grain-producer-and-top-beef-exporter-study-shows (Accessed August 2022).
Euromonitor, 2021. Processed Meat, Seafood and Alternatives To Meat in Brazil - December 2021. https://www.euromonitor.com/processed-meat-seafood-and-alternatives-to-meat-in-brazil/report (Accessed August 2022).
FAIRR, 2022. Alternative Protein Market | FAIRR. https://www.fairr.org/sustainable-proteins/food-tech-spotlight/building-esg-into-food-tech/ (Accessed August 2022).
FAO, 2020. COVID-19 and malnutrition: situation analysis and options in Africa. COVID-19 and Malnutrition: Situation Analysis and Options in Africa. https://doi.org/10.4060/ca9896en (Issue July).
FAO, 2020. Maintaining a Healthy Diet During the COVID-19 Pandemic. FAO. https://doi.org/10.4060/ca8380en.
Geels, F.W., 2002. Technological transitions as evolutionary reconfiguration processes: a multi-level perspective and a case-study. Res. Policy 31 (8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8.
Geels, F.W., Sovacool, B.K., Schwanen, T., Sorrell, S., 2017. The socio-technical dynamics of low-carbon transitions. Joule 1 (3), 463–479. https://doi.org/10.1016/j.joule.2017.09.018.
Geissdoerfer, M., Savaget, P., Bocken, N.M.P., Jan, E., 2017. The circular economy - a new sustainability paradigm? J. Clean. Prod. 143, 757–768. https://doi.org/10.1016/j.jclepro.2016.12.048.
Godfray, H.C.J., Aveyard, P., Garnett, T., Hall, J.W., Key, T.J., Lorimer, J., Pierrehumbert, R.T., Scarborough, P., Springmann, M., Jebb, S.A., 2018. Meat consumption, health, and the environment. Science (New York, N.Y.) 361 (6399). https://doi.org/10.1126/SCIENCE.AAM5324.
Grossmann, L., McClements, D.J., 2021. The science of plant-based foods: approaches to create nutritious and sustainable plant-based cheese analogs. Trends Food Sci. Technol. 118, 207–229. https://doi.org/10.1016/J.TIFS.2021.10.004.
Haigh, L., de Wit, M., Daniels, C., von Colloricchio, A., Hoogzaad, J., Fraser, M., Sutherland, A.B., McClelland, J., Morgenroth, N., Heidtmann, A., 2021. The Circularity Gap Report 2021. 71. Circle Economy.
Hair, J.F., Ortinau, D.J., Harrison, D.E., 2010. Essentials of Marketing Research. 2. McGraw-Hill/Irwin, New York, NY.
Hennink, M., Kaiser, B.N., 2021. Sample sizes for saturation in qualitative research: a systematic review of empirical tests. Soc. Sci. Med. 114523.
Herrero, M., Havlík, P., Valin, H., Notenbaert, A., Rufino, M.C., Thornton, P.K., Blümmel, M., Weiss, F., Grace, D., Obersteiner, M., 2013. Biomass use, production, feed efficiencies, and greenhouse gas emissions from global livestock systems. Proc. Natl. Acad. Sci. U. S. A. 110 (52), 20888–20893. https://doi.org/10.1073/PNAS.1308149110.
Homrich, A.S., Galvão, G., Abadia, L.G., Carvalho, M.M., 2018. The circular economy umbrella: trends and gaps on integrating pathways. J. Clean. Prod. 175, 525–543. https://doi.org/10.1016/j.jclepro.2017.11.064.
Isenberg, D.J., 2010. How to start an entrepreneurial revolution. Harv. Bus. Rev. 88 (6), 40–50.
Isenberg, D., 2011. The entrepreneurship ecosystem strategy as a new paradigm for economic policy: principles for cultivating entrepreneurship. Presentation at the Institute of International and European Affairs 1 (781), 1–13.
Jabbour, C.J.C., Jabbour, A.B.L.de S., Sarkis, J., Filho, M.G., 2017. Unlocking the circular economy through new business models based on large-scale data: an integrative framework and research agenda. Technol. Forecast. Soc. Chang. https://doi.org/10.1016/j.techfore.2017.09.010 June, 0–1.
Jurgilevich, A., Birge, T., Kentala-Lehtonen, J., Korhonen-Kurki, K., Pietikäinen, J., Saikku, L., Schösler, H., 2016. Transition towards circular economy in the food system. Sustainability 8 (1), 1–14. https://doi.org/10.3390/su8010069.
Kandlikar, M., Ramachandran, G., Maynard, A., Murdock, B., Toscano, W.A., 2007. Health risk assessment for nanoparticles: a case for using expert judgment. J. Nanopart. Res. 9 (1), 137–156.
Kansheba, J.M.P., Wald, A.E., 2020. Entrepreneurial ecosystems: a systematic literature review and research agenda. J. Small Bus. Enterp. Dev. 27 (6), 943–964.
Khatami, F., Scuotto, V., Krueger, N., Cantino, V., 2021. The influence of the entrepreneurial ecosystem model on sustainable innovation from a macro-level lens. Int. Entrep. Manag. J. 1–33.
Kinney, M., 2019. Novel protein sources hold the key to creating an innovative, appealing, and sustainable array of new meat, egg, and dairy alternatives. Food Technol. 73 (6), 46–56.
Krippendorff, K., 2013. Content Analysis: An Introduction to Its Methodology. SAGE, Los Angeles, CA.
Lavelli, V., 2021. Circular food supply chains – impact on value addition and safety. Trends Food Sci. Technol. 114, 323–332. https://doi.org/10.1016/J.TIFS.2021.06.008.
Liamputtong, P., Ezzy, D., 2005. Qualitative Research Methods. Second. Oxford University Press, Melbourne.
Liaros, S., 2021. Circular food futures: what will they look like? Circ. Econ. Sustain. 1 (4), 1193–1206. https://doi.org/10.1007/S43615-021-00082-5.
Machado, P.G., Cunha, M., Walter, A., Faaij, A., Guilhoto, J.J.M., 2020. The potential of a bioeconomy to reduce Brazilian GHG emissions towards 2030: a CGE-based life cycle analysis. Biofuels Bioprod. Biorefin. 14 (2), 265–285. https://doi.org/10.1002/bbb.2064.
Maina, S., Kachrimanidou, V., Koutinas, A., 2017. A roadmap towards a circular and sustainable bioeconomy through waste valorization. Curr. Opin. Green Sustain. Chem. 8, 18–23.
Mak, T.M.W., Xiong, X., Tsang, D.C.W., Yu, I.K.M., Poon, C.S., 2020. Sustainable food waste management towards circular bioeconomy: policy review, limitations and opportunities. Bioresour. Technol. 297. https://doi.org/10.1016/j.biortech.2019.122497 (Elsevier Ltd.).
Marshall, B., Cardon, P., Poddar, A., Fontenot, R., 2013. Does sample size matter in qualitative research: a review of qualitative interviews in IS research. J. Comput. Inf. Syst. 54 (1), 11–22.
Maximo, Y.I., Hassegawa, M., Verkerk, P.J., Missio, A.L., 2022. Forest bioeconomy in Brazil: potential innovative products from the forest sector. Land 11 (8), 1297.
Miranda, B.V., Monteiro, G.F.A., Rodrigues, V.P., 2021. Circular agri-food systems: a governance perspective for the analysis of sustainable agri-food value chains. Technol. Forecast. Soc. Chang. 170 (May), 120878. https://doi.org/10.1016/j.techfore.2021.120878.
Morgan, M.G., Keith, D., 1995. Subjective judgments by climate experts. Environ. Sci. Technol. 29 (10), 468–476.
Morgan, M.G., Pitelka, L.F., Shevliakova, E., 2001. Elicitation of expert judgments of climate change impacts on Forest ecosystems. Clim. Chang. 49, 279–307.
Morone, P., D'Adamo, I., Cianfroni, M., 2022. Inter-connected challenges: an overview of bioeconomy in Europe. Environ. Res. Lett. 17, 114031.
Newton, P., Blaustein-Rejto, D., 2021. Social and economic opportunities and challenges of plant-based and cultured meat for rural producers in the US. Front. Sustain. Food Syst. 5, 10. https://doi.org/10.3389/FSUFS.2021.624270/BIBTEX.
OECD, FAO, 2021. OECD-FAO Agricultural Outlook 2021-2030 (OECD-FAO Agricultural Outlook). OECD. https://doi.org/10.1787/19428846-EN.
Pagoropoulos, A., Pigosso, D.C.A., McAloone, T.C., 2017. The emergent role of digital Technologies in the Circular Economy: a review. Procedia CIRP 64, 19–24. https://doi.org/10.1016/j.procir.2017.02.047.
Park, H., Grundmann, P., 2022. What does an inclusive bioeconomy mean for primary producers? An analysis of european bioeconomy strategies. J. Environ. Policy Plan. https://doi.org/10.1080/1523908X.2022.2094353.
Poore, J., Nemecek, T., 2018. Reducing food's environmental impacts through producers and consumers. Science 360 (6392), 987–992. https://doi.org/10.1126/science.aaq0216.
QDA Miner, 2017. Qualitative data analysis software. Retrieved from https://provalisresearch.com/products/qualitative-data-analysis-software (Accessed December 2017).
Qureshi, F., Yusuf, M., Kamyab, H., Vo, D.V.N., Chelliapan, S., Joo, S.W., Vasseghian, Y., 2022. Latest eco-friendly avenues on hydrogen production towards a circular bioeconomy: currents challenges, innovative insights, and future perspectives. Renew. Sust. Energ. Rev. 168, 112916.
Rajput, S., Singh, S.P., 2019. Connecting circular economy and industry 4.0. Int. J. Inf. Manag. 49 (March), 98–113. https://doi.org/10.1016/j.ijinfomgt.2019.03.002.
Rampasso, I.S., Quelhas, O.L.G., Anholon, R., Silva, D.A.L., Pontes, A.T., Miranda, J.D.A., Dias, J.O., 2021. The bioeconomy in emerging economies: a study of the critical success factors based on life cycle assessment and Delphi and fuzzy-Delphi methods. Int. J. Life Cycle Assess. 1254–1266. https://doi.org/10.1007/s11367-021-01913-1.
Reis, G.G., Heidemann, M.S., Borini, F.M., Molento, C.F.M., 2020. Livestock value chain in transition: cultivated (cell-based) meat and the need for breakthrough capabilities. Technol. Soc. 62 (June), 101286. https://doi.org/10.1016/j.techsoc.2020.101286.
Rodrigues, V.P., Pigosso, D.C.A., McAloone, T.C., 2019. Business cases for ecodesign implementation: a simulation-based framework. J. Clean. Prod. 234, 1045–1058. https://doi.org/10.1016/j.jclepro.2019.06.289.
Rosa, P., Sassanelli, C., Urbinati, A., Chiaroni, D., Terzi, S., 2020. Assessing relations between circular economy and industry 4.0: a systematic literature review. Int. J. Prod. Res. 58 (6), 1662–1687. https://doi.org/10.1080/00207543.2019.1680896.
Rubio, N.R., Xiang, N., Kaplan, D.L., 2020. Plant-based and cell-based approaches to meat production. Nat. Commun. 11 (1), 1–11. https://doi.org/10.1038/s41467-020-20061-y.
Salvador, R., Puglieri, F.N., Halog, A., Andrade, F.G.de, Piekarski, C.M., de Francisco, A.C., 2021. Key aspects for designing business models for a circular bioeconomy. J. Clean. Prod. 278. https://doi.org/10.1016/j.jclepro.2020.124341 (Elsevier Ltd.).

Steffen, W., Stafford Smith, M., 2013. Planetary boundaries, equity and global sustainability: why wealthy countries could benefit from more equity. Curr. Opin. Environ. Sustain. 5 (3), 403–408. https://doi.org/10.1016/j.cosust.2013.04.007.

Stegmann, P., Londo, M., Junginger, M., 2020. The circular bioeconomy: its elements and role in european bioeconomy clusters. Resour. Conserv. Recycl. 6, 100029. https://doi.org/10.1016/j.rcrx.2019.100029.

Stephens, S., McLaughlin, C., Ryan, L., Catena, M., Bonner, A., 2022. Entrepreneurial ecosystems: multiple domains, dimensions and relationships. J. Bus. Ventur. Insights 18, e00344.

Takefuji, Y., 2021. Sustainable protein alternatives. Trends Food Sci. Technol. 107, 429–431. https://doi.org/10.1016/J.TIFS.2020.11.012.

Talmar, M., Walrave, B., Podoynitsyna, K.S., Holmström, J., Romme, A.G.L., 2020. Mapping, analyzing and designing innovation ecosystems: the ecosystem pie model. Long Range Plan. 53 (4), 101850.

The Danish National Bioeconomy Panel, 2018. Proteins for the future. https://mfvm.dk/fileadmin/user_upload/MFVM/Miljoe/Biooekonomi/Recommendations_from_the_National_Bioeconomy_Panel_Proteins_for_the_future__PDF_.pdf%0Ainternal-pdf://65.182.131.130/Recommendations_from_the_National_Bioeconomy_P.pdf (Accessed July 2022).

The Good Food Institute, 2021. 2020 State of the Industry Report - Fermentation: Meat, Eggs and Dairy.

Tukker, A., 2015. Product services for a resource-efficient and circular economy - a review. J. Clean. Prod. 97, 76–91. https://doi.org/10.1016/j.jclepro.2013.11.049.

Tura, N., Hanski, J., Ahola, T., Ståhle, M., Piiparinen, S., Valkokari, P., 2019. Unlocking circular business: a framework of barriers and drivers. J. Clean. Prod. 212, 90–98. https://doi.org/10.1016/j.jclepro.2018.11.202.

United Nations, 2019. Sustainable consumption and production and the SDGs - goal 12. https://www.un.org/sustainabledevelopment/sustainable-consumption-production/ (Accessed June 2022).

Vaismoradi, M., Turunen, H., Bondas, T., 2013. Content analysis and thematic analysis: implications for conducting a qualitative descriptive study. Nurs. Health Sci. 15 (3), 398–405.

Van Lancker, J., Wauters, E., van Huylenbroeck, G., 2016. Managing innovation in the bioeconomy: an open innovation perspective. Biomass Bioenergy 90, 60–69. https://doi.org/10.1016/j.biombioe.2016.03.017.

Vandenberghe, L.P.S., Valladares-Diestra, K.K., Bittencourt, G.A., Torres, L.Z., Vieira, S., Karp, S.G., Soccol, C.R., 2022. Beyond sugar and ethanol: the future of sugarcane biorefineries in Brazil. Renew. Sust. Energ. Rev. 167, 112721.

Wei, X., Liu, Q., Pu, A., Wang, S., Chen, F., Zhang, L., Zhang, Y., Dong, Z., Wan, X., 2022. Knowledge mapping of bioeconomy: a bibliometric analysis. J. Clean. Prod. 373. https://doi.org/10.1016/j.jclepro.2022.133824 (Elsevier Ltd.).

World Economic Forum, 2019. How can we produce enough protein to feed 10 billion people? | world economic forum. https://www.weforum.org/agenda/2019/01/how-can-we-produce-enough-protein-to-feed-10-billion-people/ (Accessed June 2022).

Wreford, A., Bayne, K., Edwards, P., Renwick, A., 2019. Enabling a transformation to a bioeconomy in New Zealand. Environ. Innov. Soc. Transit. 31, 184–199. https://doi.org/10.1016/j.eist.2018.11.005.