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Innovation adoption in the agri-food system: a model proposition
Adoção de Inovação no Sistema Agroalimentar: proposição de um modelo

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Thesis presented at the Administration Department of the Faculty of Economics, Administration, Accounting, and Actuary at the University of São Paulo, as part of the requirements for obtaining a Doctor of Science degree.

Supervisor: Prof. Dr. Eduardo Pinheiro Gondim de Vasconcellos

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DEDICATION

I dedicate this work to my goddaughter Luisa, the source of joy and family unity. To my mom, Vanessa, for guiding me on all the paths I have traveled so far, for her unconditional support, advice, strength, and patience. To my dad, Eduardo, for being an inspiration of joy. To my husband and partner, Lipe, for believing in me so much, often more than I believe in myself. To Isa and Grandma Flora, strong women who are part of who I am. To Rudi, for always believing that this thesis would be completed.

Dedico este trabalho a minha afilhada Luisa, fonte de alegria e união da família. À minha mãe, Vanessa, por me guiar em todos os caminhos que percorri até hoje, pelo apoio incondicional, conselhos, força e paciência. Ao meu pai, Eduardo, por ser inspiração de alegria. Ao meu marido, Lipe, por acreditar tanto em mim, muitas vezes mais do que eu mesma. À Isa e à vó Flora, mulheres fortes que fazem parte de quem eu sou. Ao Rudi, por sempre ter acreditado que esta tese ficaria pronta.

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“Toda tese tem uma história, que tem páginas engraçadas, alegres, divertidas e outras que são difíceis, pesadas, tristes. Aprendemos com todas elas e não são lições de consumo imediato, pelo contrário serão incorporadas na nossa vida. No limite, nós somos o maior objeto da tese, pois enquanto sujeito dela vivemos um embate de forças internas e externas que nos ensina muito sobre nós mesmos.”

(FREITAS, M. E. de. Viver a tese é preciso! Reflexões sobre aventuras e desventuras da vida acadêmica. Revista de Administração de Empresas, v. 42, n. 1, p. 88-93, 2002.)

ABSTRACT

The agri-food system is of great economic importance, providing a significant contribution to countries' gross domestic product (GDP), and is responsible for feeding an ever-growing population, even in the face of challenges related to natural resource scarcity and climate change. These challenges mean that the sector has significant potential for innovation development and adoption. One of the great innovations in the agri-food system is alternative protein, a product capable of replicating the taste, texture, and appearance of meat, but derived from vegetables, plants, and other non-conventional sources. Innovation adoption occurs when an organization chooses to adopt an innovation, whether through new products, processes, systems, or other means, generated internally or externally acquired. The literature on the subject presents innovation adoption models that provide an efficient and structured way to analyze innovation adoption. However, studies dealing with adoption models in the agri-food system are scarce. Therefore, the objective of this thesis is to propose a model of innovation adoption for the agri-food system that can identify the constituent elements of adoption and facilitate its implementation in the sector. To achieve this objective, the thesis is divided into three articles. Article 1 aimed to identify the main innovations that are adopted in the agri-food system, through a systematic literature review. The purpose of article 2 was to identify the perceptions of innovation characteristics that may influence innovation adoption, and article 3 aimed to analyze the influence of external variables and internal characteristics on innovation adoption. Articles 2 and 3 used semi-structured interviews with managers involved in the process of innovation adoption in the agri-food system in Brazil and content analysis and thematic analysis was used to analyze the data. At the end of the thesis is proposed an innovation adoption model for the agri-food system, which considers the perceived characteristics of the innovation, the influence of external variables and also its internal characteristics. The model is a valid contribution for the scientific community and in practical terms, as it provides an organized and structured approach to guide the innovation adoption and it permits to analyze the influence of the different dimensions that most affect agri-food system organizations in the adoption process.

Keywords: Innovation adoption; Agri-food system; Innovation adoption model; Alternative proteins.

RESUMO

O sistema agroalimentar possui grande importância econômica ao contribuir de forma significativa para o produto interno bruto (PIB) dos países, além de ser responsável pela alimentação da população em constante crescimento, enfrentando desafios relacionados à escassez de recursos naturais e alterações climáticas. Estes desafios fazem com que o setor tenha um potencial significativo para o desenvolvimento de tecnologias e a adoção de inovações. Uma das grandes inovações no sistema agroalimentar é a proteína alternativa, um produto capaz de replicar o sabor, textura e aparência da carne, porém derivado de vegetais, plantas e outras fontes não convencionais. A adoção de inovação ocorre quando uma organização opta por adotar uma inovação, seja através de novos produtos, processos, sistemas ou outros meios, gerados internamente ou adquiridos externamente. A literatura sobre adoção de inovação apresenta modelos de adoção que fornecem uma maneira eficiente e estruturada de analisar a adoção de inovação. No entanto, estudos que tratam de modelos específicos para o sistema agroalimentar são escassos. Assim, o objetivo desta tese é propor um modelo de adoção de inovação para o sistema agroalimentar que possa identificar os elementos constituintes da adoção e facilitar a sua implementação no setor. Para atingir este objetivo a tese está dividida em 3 artigos. O artigo 1 teve como objetivo identificar as principais inovações que são adotadas no sistema agroalimentar, através de uma revisão sistemática da literatura. O artigo 2 objetivou identificar as características percebidas da inovação que podem influenciar a adoção da inovação, enquanto o artigo 3 teve como objetivo analisar a influência de variáveis externas e de características internas na adoção da inovação. Nos artigos 2 e 3 entrevistas semiestruturadas com gestores envolvidos no processo de adoção de inovação no sistema agroalimentar no Brasil foram utilizadas para coleta de dados e utilizou-se análise de conteúdo e análise temática para análise dos dados. Ao final da tese, propõe-se um modelo de adoção de inovação para o sistema agroalimentar, que leva em consideração as características percebidas da inovação, a influência de variáveis externas e também das características internas. O modelo é uma contribuição válida para a comunidade científica e também apresenta contribuições práticas, pois fornece uma abordagem organizada e estruturada para orientar a adoção da inovação e permite analisar a influência das diferentes dimensões que mais afetam as organizações do sistema agroalimentar no processo de adoção de inovações.

Keywords: Adoção de inovação; Sistema agroalimentar; Modelo de adoção de inovação; Proteínas alternativas.

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SUMMARY

1 INTRODUCTION

The agri-food system is a strategic sector for the Brazilian economy, ranging from grain production to livestock farming and the manufacture of industrialized food products. The sector is responsible for a sizable portion of the Gross Domestic Product - GDP, reaching record levels of 26.6% in 2021 and 24.8% in 2022. It is also a relevant vector for the development of technologies and innovations in the sector and a potential contributor to the food security of the population. Innovation in the agri-food system is an increasingly relevant issue as the sector is constantly facing challenges related to environmental sustainability, rising input costs, especially in agricultural activities, and meeting the demands of an ever-growing population (CEPEA & CNA, 2023; Teklu, Simane & Bezabih, 2023; Timpanaro et al., 2023).

Given this scenario and the possibility for companies to meet the challenges and remain competitive through innovation, there is a need to identify elements that can help organizations in the agri-food system to adopt innovation. Adoption refers to the decision by an individual or organization to use or not use an innovation and can occur through the adoption of new products and services, whether they are internally generated or externally acquired. Innovation adoption can also occur through the adoption of new processes, programs, systems, equipment and/or policies, and also have the goal of generating effectiveness for the organization and keeping it up to date and updated to market changes (Daft, 1978; Damanpour & Gopalakrishnan, 1998; Davis, 1989; Rogers, 2003; Singh et al., 2023).

The field of organizational innovation adoption offers great opportunities and there are different studies that propose models of innovation adoption. Despite of this, the current literature presents an insufficient understanding of how agri-food organizations adopt innovations today, and little is known about models of organizational innovation adoption that consider the characteristics of the agri-food system. The agri-food system has its own characteristics that differentiate it from other industries. Over the last 30 years, the sector has undergone major changes, moving from subsistence production to a complex production system, and technology has been recognized as a key development factor for organizations. Despite this, the sector has traditionally been seen as technologically lagging behind other industries, and the innovation adoption in the sector faces difficulties such as low investment in R&D, regulatory and governmental issues, non-standardized processes,

and lack of collaboration in the sector (ABAG, 2020; Batterink, Wubben, Klerkx & Omta., 2010; Fait et al., 2019; Kabbiri et al., 2017; Klerkx & Rose, 2020; Makkonen et al., 2016; Montes de Oca Munguia et al., 2021; Stroh, Mention & Duff, 2023; Williams, Dwivedi, Lal & Schwarz, 2009).

Observing these gaps, it is necessary to propose a model of innovation adoption for the agri-food system, which can identify the constituent elements of the adoption and facilitate its implementation in the sector, as the models are able to provide a structured way to analyze adoption and provide a method to study the impact of different dimensions on the adoption process. Among the various and different possibilities of innovation adoption in the agri-food system, it has been chosen to analyze the adoption of alternative proteins due to the potential of this market and the high level of investment in the product (Guan et al., 2021; Morais-da-Silva, Reis, Sanctorum & Molento, 2022; Sinke & Odegard, 2021).

Alternative proteins are defined as protein sources that are not derived from animals, but from vegetables, plants and other non-conventional sources, or those that are produced from animal cells grown in laboratories without the need to raise and slaughter animals, and that are capable of replicating the taste, texture and appearance of animal proteins. The analysis of the adoption of alternative proteins is relevant given the growth projections of this market and the high investments made by major companies in this sector. Between 2016 and 2020, 460 million dollars were invested in alternative proteins by companies in the agri-food system around the world. In Brazil, the largest food producers have announced investments and partnerships for the production of them (Abrahao, Rufino, Reis & Cabral, 2023; Bryant & Van der Weele, 2021; Gerhardt et al., 2020; GFI, 2022b; Guan et al., 2021; Souza, 2021; Stroh, Mention & Duff, 2023).

To this end, the objective of this thesis is to propose an innovation adoption model for the agri-food system that identifies the constituent elements of alternative proteins adoption to facilitate its implementation in the sector. To validate and enrich the proposed model, it was applied with twenty-nine managers and leaders involved in the process of adopting alternative proteins, with the purpose of exploring and evaluating each of the elements.

The thesis is structured in three articles, one theoretical and the others empirical. The thesis is formed by: this introduction, which presents the central research objective, justifications and contributions of the research; the second chapter that presents the structure of the thesis, the relationship between the articles, the methodological aspects of

each one and the thesis theoretical framework, which will address the initial concepts to be developed in the articles; the presentation of the 3 full articles; the last chapter, which presents the common considerations resulting from the three articles; and, finally, the references and appendices.

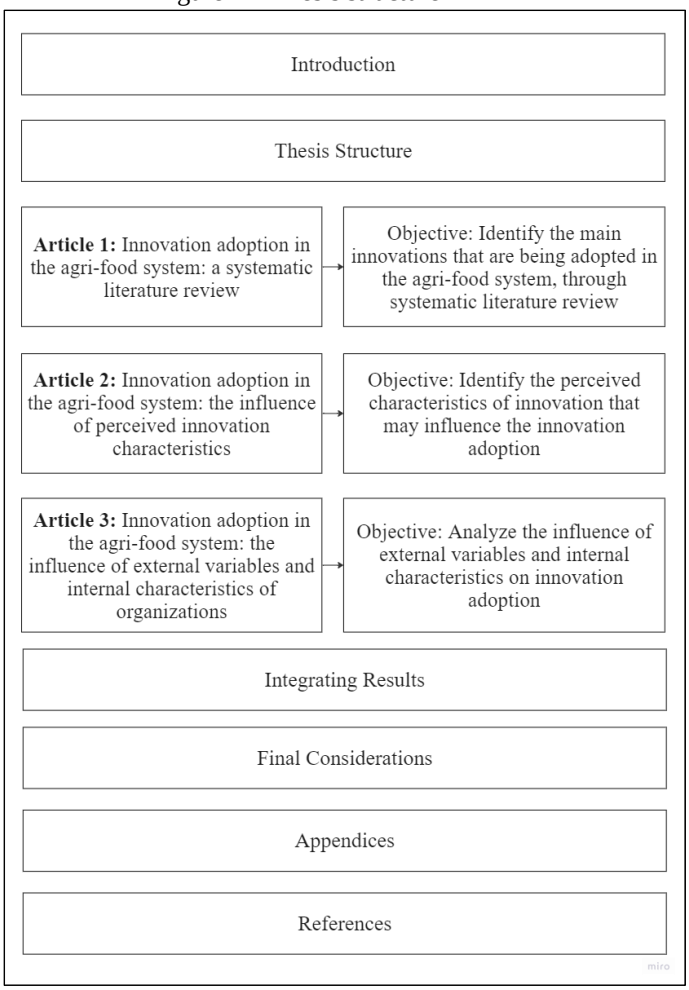
2 THESIS PRESENTATION

2.1 Thesis Structure

The methodological matrix used in this thesis is presented in Table 1. It shows the central objective of the thesis, the articles that make it up and the main objective of each of them, as well as the research method used.

This work is structured in seven sections, in addition to the appendices and references, as presented in Figure 1.

Figure 1 – Thesis structure



Source: elaborated by the author

Table 1 – Thesis overview

RESEARCH QUESTION	**What are the dimensions that influence the innovation adoption in the agri-food system?**				
GENERAL OBJECTIVE	ARTICLE	GENERAL OBJECTIVE	SPECIFIC OBJECTIVES	DATA COLLECTION	ANALYSIS TECHNIQUE
Propose an innovation adoption model for the agri-food system that identifies the constituent elements of alternative proteins adoption to facilitate its implementation in the sector	Article 1 - Innovation adoption in the agri-food system: a systematic literature review	Identify the main innovations that are being adopted in the agri-food system, through systematic literature review	i) Clarify which paths and areas of research should be considered by the organizations that operate in the agri-food system ii) Gather contemporary innovations in the agri-food system iii) To collect different perspectives on studies related to the innovation adoption theory in the agri-food system	Systematic literature review	Content analysis
	Article 2 - Innovation adoption in the agri-food system: the influence of perceived innovation characteristics	Identify the perceived innovation characteristics that may influence the innovation adoption	i) To identify the perceived innovation characteristics that are relevant to the agri-food system ii) To identify the influence of the perceived innovation characteristics in the process of innovation adoption in the agri-food system.	Semi-structured interviews	Content analysis
	Article 3 - Innovation adoption in the agri-food system: the influence of external variables and internal characteristics of organizations	Analyze the influence of external variables and internal characteristics on innovation adoption	i) To explore the influence of network externalities, competitive environment, and legislation in the innovation adoption ii) To explore the influence of innovativeness, business relationship and key individuals in the agri-food system iii) To identify the influence of external variables and internal characteristics in the process of innovation adoption in the agri-food system	Semi-structured interviews	Content analysis

The introduction presents the contextualization of the thesis as well as the aims and contributions of the research. The following section presents the structure of the thesis, the main objectives and methods used in each article and the review of additional literature that was not covered in the articles. After that, article 1 is presented, entitled "Adoption of innovations in the agri-food system: a systematic literature review", which aimed to identify the main innovations adopted in the agri-food system. The specific objectives of article 1, are: to clarify which research paths and areas should be considered by organizations operating in the agri-food system; to collect contemporary innovations in the agri-food system; to collect different perspectives on studies related to the theory of innovation adoption in the agri-food system. This article was developed through a systematic literature review, following the PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analysis - guidelines for bibliometric work. Analyses were conducted using R software and content analyses technique (Bardin, 2016; Moher, Liberati, Tetzlaff & Altman, 2009).

Article 2, entitled 'Adoption of innovation in the agri-food system: the influence of perceived characteristics of innovation', had as its main objective to identify the perceived characteristics of innovation that may influence the adoption of innovation. This objective was broken down into two specific objectives: to identify the perceived characteristics of innovation that are relevant to the agri-food system; to validate the influence of perceived characteristics on the innovation adoption process in the agri-food system. This article consisted of a literature review, which identified the perceived characteristics of innovation that can influence the adoption of innovation in the agri-food system, and a field research, of exploratory nature, based on semi-structured interviews with managers and executives involved in the process of adoption of alternative proteins in the agri-food system in Brazil. The main analyses used in this article were the content analysis technique, divided into two types: frequency and thematic (Bardin, 2004, 2016; Minayo, 2014).

In article 3, the main objective was to analyze the influence of external variables and internal characteristics on innovation adoption. The main objective was broken down into specific objectives: to explore the influence of network externalities, the competitive environment and legislation on innovation adoption; to explore the influence of innovativeness, business relationships and key individuals in the agri-food system; to identify the influence of external variables and internal characteristics on the process of innovation adoption in the agri-food system. This article, entitled "Adoption of innovation in the agri-food system: the influence of external variables and internal characteristics of

organizations", consisted of a literature review, which identified the external variables and internal characteristics of organizations that influence the adoption of innovation in the agri-food system, and a field research, of an exploratory nature, based on semi-structured interviews with the same managers and executives from article 2, that are involved in the adoption of alternative proteins in the agri-food system in Brazil. The article used the technique of content analysis, divided into two types: frequency and thematic (Bardin, 2004, 2016; Minayo, 2014).

The integration of the results is presented in the section six. It presents the proposed innovation adoption model for the agri-food system, main objective of the thesis, with the dimensions that composes it and the interrelationship between them. The last section presents the final considerations of the thesis and the final conclusions. The appendices and references used in the studies are presented at the end.

2.2 Theoretical Reference

This section presents the review of additional literature that was not covered in the three articles that composes the thesis. To achieve the objective of proposing a model of innovation adoption for the agri-food system, it is necessary to explore the existing literature on innovation adoption models. Moreover, information on alternative proteins is presented, since they will be the object used in this thesis to apply the proposed model.

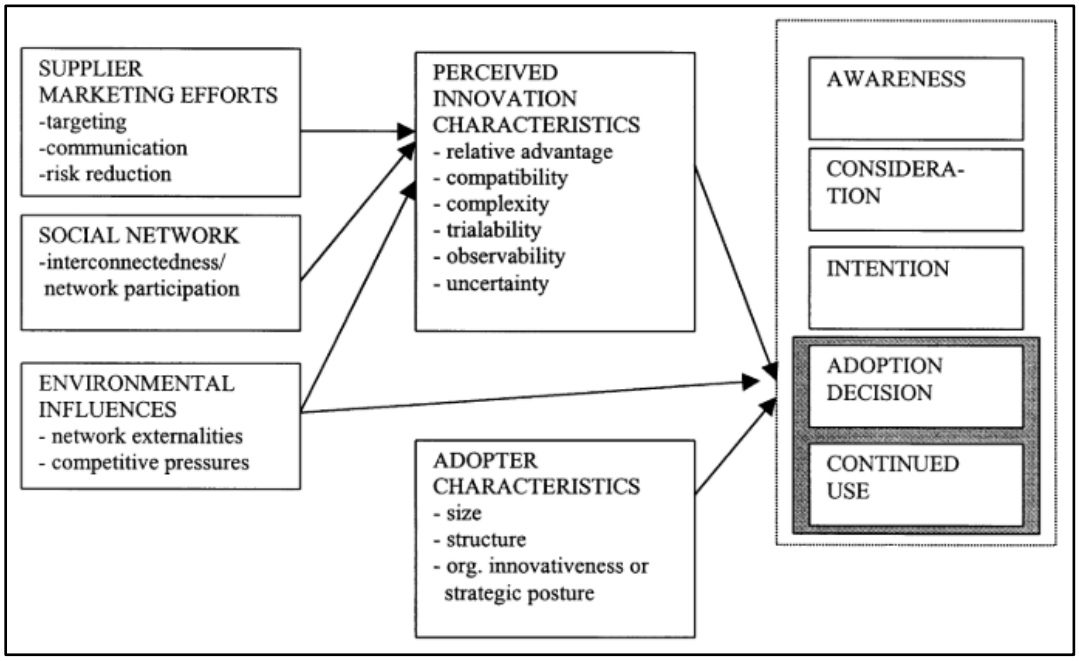
2.2.1 Organizational Innovation Adoption Models

A model proposed in 2002 is considered a reference in the literature about organizational innovation adoption and summarizes previous basic studies and adoption models available in literature. The model includes both the decision of an organization and the decision of individuals within an organization to innovate and it is presented in Figure 2 (Frambach & Schillewaert, 2002; Heinze & Heinze, 2020; Zach, Nicolau & Sharma, 2020).

The model has the perceived innovation characteristics as a central starting point and three aspects of influence on the adoption behavior: marketing efforts of the supplier, social network, and environmental influences. In addition, the model considers three organizational-level characteristics that can influence the adoption decision: organizational size, organizational structure, and organizational innovation capacity or strategic posture.

The model also considers the different stages of the adoption process: awareness, consideration, intention, adoption decision, and continued use (Frambach & Schillewaert, 2002; Heinze & Heinze, 2020; Zach, Nicolau & Sharma, 2020).

Figure 2 - Conceptual framework of organizational innovation adoption proposed by Frambach and Schillewaert



Source: Adapted from Frambach and Schillewaert (2002)

The characteristics of the dimensions that composes the model are presented in Table 2, along with the main related studies that also mention them, indicating whether they influence innovation adoption positively or negatively. It is possible to affirm that the dimensions Complexity and Uncertainty have a negative influence in the organizational innovation adoption, while the other dimensions can promote the adoption. The dimensions Competitive Environment and Organizational Structure can influence positively or negatively, depending on other characteristics (Frambach & Schillewaert, 2002; Heinze & Heinze, 2020; Zach, Nicolau & Sharma, 2020).

Table 2 - Dimensions from Frambach and Schillewaert framework and their characteristics

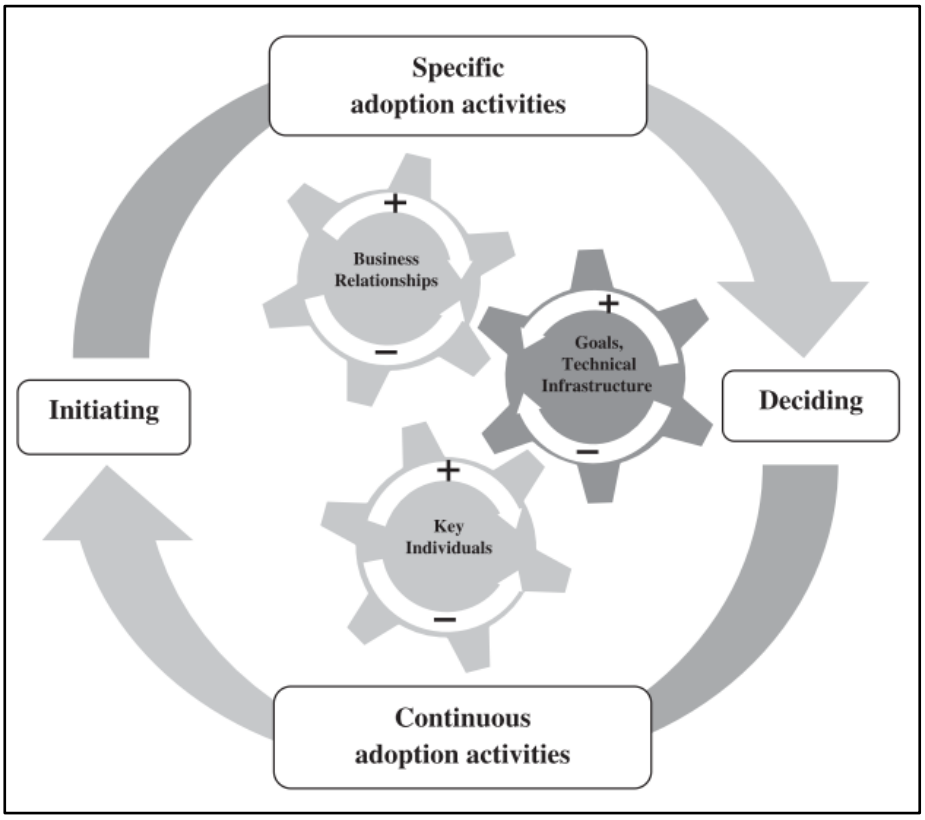
	Related studies	Independent Dimensions	Characteristics	Influence
1. Perceived innovation characteristics	(Frambach & Schillewaert, 2002; Nooteboom, 1989; Ostlund, 1974; Rogers,	1.1 Relative or economic advantage	How much is considered better than the idea being replaced.	+
		1.2 Compatibility	How much is seen as consistent with potential consumers' existing values, past experiences and needs.	+

	2003; Tornatzky & Klein, 1982)	1.3 Trialability	Degree to which the potential adopter considers it possible to try the innovation.	+
		1.4 Observability	How visible the results are.	+
		1.5 Complexity	How difficult is to use or understand.	-
		1.6 Uncertainty	Degree of technical, financial and/or social uncertainty.	-
2. Supplier marketing efforts	(Robertson & Gatignon, 1986)	2.1 Targeting	Specific targeting of innovations to selected potential adopters.	+
		2.2 Communication	Create awareness and influence potential customers' perceptions.	+
		2.3 Risk reduction	Techniques to reduce risk of use, operation, implementation or financial.	+
3. Social network	(Rogers, 2003; Zaltman, Holbek & Duncan, 1973)	3.1 Interconnectedness	Connections with different industries and information sharing.	+
4. Environmental influences	(Katz & Shapiro, 1994; Robertson & Gatignon, 1986)	4.1 Network externalities	When partners have already adopted the innovation, increasing usefulness.	+
		4.2 Competitive environment	Competitive pressures can drive adoption. Non-adoption may result in competitive disadvantage.	+-
5. Adopter characteristics	(Damanpour, 1996; Kimberly & Evanisko, 1981; Nooteboom,	5.1 Size	Larger organizations seek harder to adopt innovation; Still, smaller organizations are more flexible.	+
	1989; Zaltman, Holbek & Duncan, 1973)	5.2 Innovativeness or strategic posture	Receptiveness to innovative ideas and products.	+
		5.3 Organization structure	How formalization and centralization can affect adoption.	+-

Source: Adapted from Frambach and Schillewaert (2002)

In the context of the agri-food system, a seminal paper conducted with companies in the food sector analyzed managerial values of change, innovative intentions and innovative technological outcomes. The study concluded that the presence of human resources dedicated exclusively to innovation processes is necessary for the occurrence of episodes of innovation and creativity within organizations. A recent study of slaughterhouses and a study of the dairy value chain, confirm that the presence of key individuals who have the ability to influence the perceptions of their peers can improve the acceptance of innovations by creating an environment for innovation adoption activities in a systematic, intensive, and targeted manner (Ettlie, 1983a; Makkonen et al., 2016; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Wairimu, Mburu, Ndambi & Gachuiri., 2022).

Figure 3 - Organization innovation adoption model



Source: Makkonen et al. (2016)

In addition to the influence of key individuals, the influence of business relationships on adoption is reinforced by one of these studies, as the knowledge that supports the adoption decision comes from internal and external sources, including technology suppliers, companies in other industries, and competitors. To make up the proposed innovation adoption model, the study adds as the third dimension the goals and technical infrastructure. The dimensions influence each other, increasing (+) or decreasing (-) continuous adoption activities or specific adoption activities, as shown in Figure 3 (Makkonen et al., 2016).

2.2.2 Demand for Innovation Adoption in the Agri-food System

The agri-food system is facing major challenges. Population growth will lead to an increase in food production of about 70%, and finding ways to feed the population in a sustainable, efficient, and safe way is an urgent need. Livestock production accounts for 14.5% of total greenhouse gas emissions, and if current trends in meat consumption continue, it is estimated that greenhouse gas emissions will increase by up to 80% by 2050. Faced with

this problem, in 2017, around 24% of the world's population claimed to be trying to reduce their meat consumption. In Brazil, this number was around 26 percent, in the United States it was 18 percent, and in China it was around 37 percent (Bassi et al., 2022; Bryant & Sanctorum, 2021; Euromonitor International, 2019; Morais-da-Silva et al., 2022; OECD/FAO, 2017).

Innovations in the agri-food system have been developed to address these challenges and to meet consumer demand for healthy products that fit with their lifestyles and preferences. One promising example is alternative proteins, which have been developed as an alternative way to consume protein without negative environmental and health impacts (Bassi et al., 2022; Bryant & Van der Weele, 2021; Gerhardt et al., 2020; Lynch & Pierrehumbert, 2019; Morais-da-Silva et al., 2022; OECD/FAO, 2017; Timpanaro et al., 2023; Van Dooren & Brink, 2017).

Alternative proteins are protein sources that are not derived from animals, but from vegetables, plants, insects, algae, and other non-conventional sources. They are also named as plant-based meats and fermentation-based meats, and the promise from the producers is that they can replicate the taste, texture, and appearance of animal proteins. There are also alternative animal-based proteins, named cultured meats, which are produced from animal cells grown in laboratories without the need to raise and slaughter animals (Bryant & Van der Weele, 2021; GFI, 2022b, 2022a, 2022c; Guan et al., 2021).

In the United States, a study of meat alternative protein consumption found that sales of these products grew 3.7% between 2012 and 2014. In 2016, 70% of meat eaters used an alternative protein at least once a week, and 22% said they used these substitutes more often than in the previous year. In 2021, sales of plant-based foods grew 6.2%, and projections showed that consumption of alternative proteins in the United States would reach $5.9 billion by 2022, growing 6.6% per year from 2016. These projections were exceeded, and the total market value reached $7.4 billion in 2022. In Brazil, a survey shows that 37% of respondents have already included alternative proteins in their diet (GFI, 2020, 2021; Plant Based Foods Association, 2022; Strom, 2016).

It is predicted that in the next ten years, approximately one third of the world's meat supply will come from alternative proteins, and that in twenty years, only 40% of the world's meat consumption will derives from animal sources. Cultured meat will grow at an annual rate of 41%, and between 2025 and 2040 it will surpass global consumption of other alternative proteins. The global market is expected to grow to $290 billion by 2035, with penetration increasing from 2% to 10-22% (Gerhardt et al., 2020; Witte et al., 2021).

Innovation is an increasingly relevant issue for the agri-food system and there is a constant need for organizations to adopt innovations in order to maintain the sector as a strategic instrument for the development of countries. This scenario makes the agri-food system a fertile field for the development of technologies and innovations, and it is necessary to identify the main innovations that have been adopted in the agri-food system in recent years, which will be done in the next section of this thesis.

ARTICLE 1 – Innovation adoption in the agri-food system: a systematic literature review

SUMMARY

The agri-food system is responsible for boosting the gross domestic product (GDP) of several countries, creating jobs, and feeding populations around the world. Several technologies have been developed by and for the agri-food system to remain competitive in an unstable and dynamic scenario. Innovation and its adoption process are complex constructs, approached from different perspectives. Therefore, the objective of this study was to identify, through a systematic review, the main innovations that are being adopted in the agri-food system, to clarify the paths and areas of research that organizations operating in the agri-food system should consider in order to remain competitive. The results showed that innovations are mainly related to the adoption of information and communication technologies (ICTs), the adoption of innovations in packaging, conservation methods, the use of nanotechnology and 3D printers. It was also found that the studies highlight the importance of networking and collaboration for innovation adoption processes to occur, and that innovations capable of promoting alternatives to sustainability challenges are currently considered the most attractive ans a great opportunity for the agri-food system. Thematic gaps were identified, as alternative proteins adoption by agri-food system organizations and innovation possibilities for agri-food SMEs, directing to future research about this topics.

Keywords: Innovation Adoption; Agri-food System; Sustainable Innovations.

1 INTRODUCTION

Over the past 30 years, subsistence production has been replaced by a complex and renovated agri-food system. Knowledge, once seen as a privilege, has become a development factor for companies, producers, farmers, stakeholders, and those involved in the agri-food chain. The implementation of new food solutions has become a global challenge and a relevant opportunity from an economic point of view, being related to environmental, sustainability and public health issues. Innovation, in the form of new products, processes and services, changes the market and creates new, previously non-existent consumer needs, with a direct impact on the economies of nations, as it occurs continuously and progressively. This unstable and dynamic scenario creates opportunities and challenges, and the organizations that thrive are those that can adapt to meet the changing expectations of consumers through the adoption of innovations, new forms of relationships, distribution channels and new competencies. The importance of the agri-food system for world economies and the growth in product supply and innovation opportunities

justify the importance of analyzing and monitoring changes in this scenario (Chesbrough, 2007; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Schumpeter, 1985; Tilman & Clark, 2014; Wasiq, Kamal & Ali, 2023).

From an organizational perspective, the decision to use an innovation as the best available course of action is called innovation adoption. Adoption creates changes with the goal of transforming the organization to maintain or improve its level of performance and effectiveness. Innovation adoption can be influenced by several aspects, such as internal characteristics of the organization, external influences of the environment in which it is inserted, and issues related to the innovation itself. As it is a widely studied concept, it is possible to find in the literature several publications that propose models of innovation adoption. Nevertheless, none of them is a "definitive model" and unrivaled, since the variables and dimensions related to adoption are dynamic and numerous, making this a fertile field for future research (Damanpour & Schneider, 2006; Ettlie, 1983a; Kimberly & Evanisko, 1981; Rogers, 2003; Silveira Junior, 2018; Timpanaro et al., 2023).

Despite the opportunities for competitive advantage and growth that the innovation adoption can generate for the agri-food system, the organizations that make it up still face many constraints. Agri-food is characterized as a traditional industry, with low research intensity and insufficient incentives for innovation, which makes the sector considered technologically backward compared to other industries. Most products remain on the market for a long period and new products are mostly extensions of older ones, the result of incremental innovation. Research and development (R&D) therefore has a specific character in the sector, and although many institutions and researchers are interested in discussing the topic, there is still much to be explored (ABAG, 2020; Batterink et al., 2010; Ettlie, 1983b; González-Moreno,Triguero & Sáez-Martínez, 2019; Kastelli et al., 2016; Pavitt, 1984).

Therefore, the main objective of this study is to identify, through a systematic literature review, the main innovations that are adopted in the agri-food system. As for the specific objectives, it is expected: to clarify which paths and areas of research should be considered by organizations operating in the system as a possibility of obtaining competitive advantage; gather contemporary innovations in the agri-food system; to collect different perspectives on studies related to the innovation adoption theory in the agri-food system. It is expected that the results will be fruitful from a theoretical point of view, contributing to the strengthening of studies related to the theory of innovation adoption and bringing together different perspectives on the subject. As a practical contribution, it is

expected to present contemporary innovations to industries and other actors involved in the agri-food system.

1.1 Innovation Adoption in the Agri-food System

The concept of innovation adoption has been widely studied by several authors and can be understood as the decision to use an innovation as the best available action. In contrast, rejection is the decision not to adopt the innovation. Despite the different studies related to the theme, Rogers (2003) is the central researcher that proposed the diffusion innovation theory that identify five innovation attributes that may influence the adoption, namely: i) Compatibility; ii) Relative Advantage; iii) Complexity; iv) Testability or Possibility of Experimentation; v) Visibility (Ettlie, 1983b; Rogers, 2003).

The innovation adoption has been studied in different contexts and specific industries such as the agri-food system. The agri-food system represents the integrality of operations and activities inherent to the supply of inputs, agricultural production, storage, processing, and distribution of food, and has undergone major transformations in the last 30 years. The transfer and application of external knowledge and technological changes in other sectors have strongly influenced adaptations and innovations in the agri-food system and, in a brief period, subsistence production has been replaced by complex systems. Knowledge and investment in R&D, once considered a privilege, have become a development factor for progress in the agri-food system (Silva et al., 2023; Davis & Goldberg, 1957; Malassis, 1973; Massa & Testa, 2017; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Pavitt, 1984; Timpanaro et al., 2023; Viero & Souza, 2008).

Over time, the agri-food system has developed a significant knowledge base and, to the extent possible, has provided the market with innovative products and processes, despite incipient investments in research and development. It is important to emphasize the importance of traditional knowledge for this, such as cultural manifestations, production technologies and agri-food knowledge that comes from field workers, as well as literature. Since the early 1980s, researchers have emphasized the unique properties that innovation can generate for the agri-food system, although it is a complex process involving different components of the system, which can occur through the introduction of a new ingredient, new forms of packaging or new methods of food preservation (Batterink et al., 2010; Ettlie, 1983b; González-Moreno et al., 2019; Kastelli et al., 2016; Massa & Testa, 2009; Trott & Simms, 2017).

Some specific difficulties are related to the innovation adoption in the agri-food system, such as a lack of effective knowledge about the innovation process, limited financial resources for investment in R&D, and scarce skills. In Brazil, this is compounded by the main challenges faced by industries and companies in the system, such as the country's infrastructure bottleneck and organizational management, and governance issues. If, on the one hand, advances in ICT have made it possible to standardize processes, coordinate actors in the chain and reduce logistics costs, on the other hand, the agri-food system is facing challenges related to the impact of climate change, new demands for sustainability, traceability and transparency of products and processes (ABAG, 2020; Batterink et al., 2010; Fait et al., 2019; Klerkx & Rose, 2020).

The agri-food system is highly dependent on natural resources, especially regarding the primary sector, which includes agriculture, livestock, fisheries, mineral extraction, and is responsible for the production of raw materials, generating significant direct and indirect negative environmental impacts. For more than twenty years, the scarcity of food protein resources has been considered an acute problem and warnings have been issued about the problems that the population explosion of the 21st century will cause, mainly related to issues of food supply and environmental degradation. According to the Food and Agriculture Organization of the United Nations, the demand for food will increase by about 60% by 2050 as the population grows. If current trends in meat consumption continue, it is estimated that by 2050 there will be an increase of up to 80% in greenhouse gas emissions from food production and global deforestation, as well as reduced life expectancy, severe negative impacts on food production and reduced food security (Castillo-Acobo et al., 2022; Batterink et al., 2010; Doelman, Stehfest, Tabeau & Van Meijl, 2019; Ettlie, 1983b; González-Moreno et al., 2019; Le Mouël & Forslund, 2017; Mitsuda, 1999; Ullah, Khan & Ahmad., 2022).

On the other hand, there are technologies and innovations that make it possible to produce food in a sustainable way, for example, by reducing the amount of water and fertilizer used and reducing greenhouse gas emissions. Innovation adoption in the agri-food system is a global challenge and a major opportunity from both an economic and an environmental perspective. Given that the planet's environmental limits have already been exceeded or are in a critical situation for many factors, such as biodiversity loss and climate change, an immediate change in food production processes and eating habits is needed. As consumers have access to information about environmental degradation and fragility, concern about the type of food they eat is growing and attracting market attention. Studies

show an acceleration in the shift to plant-based diets and a reduction in animal-based diets. 83% of the population is concerned about the environment and consumers say they want to consume in a more sustainable way (Ettlie, 1983b; González-Moreno et al., 2019; Le Mouël & Forslund, 2017; Matin et al., 2012; OECD/FAO, 2017; Van Dooren & Brink, 2017; Wickramasinghe et al., 2021).

In this scenario, meat is one of the products directly affected. Research conducted in the United States shows that the sale of alternative products to animal meat grew by 3.7% between 2012 and 2014. A survey conducted by NPD Group and Midan Marketing in 2015 in the same country showed that 70% of meat consumers used a substitute protein at least once a week and 22% said they were using these products more often than in the last year. Research states that by the end of 2022 the consumption of animal protein substitutes will reach 5.9 billion dollars, growing 6.6% per year and that by 2035 the global market for the segment could reach up to 370 billion dollars (Gerhardt et al., 2020; Strom, 2016; Swartz, 2021).

In addition to environmental issues, other factors are capable of driving food preferences. Fear of technologies and innovations used in food manufacturing and the agri-food system is one of them. Studies show that the lack of understanding of how new food technologies (such as nanotechnology, genetic modifications, agro biotechnology, cloning, among others) are used, interferes with the consumer's decision. Thus, for innovative products to be accepted, actions that clarify and inform about the technologies used are necessary. Scholars, investors, and entrepreneurs in the agri-food system claim that the necessary apparatus for reformulating it already exists. Ensuring the competitiveness of the agri-food system is a matter of collective and public interest and, to this end, investment and research on the subject are necessary (Ali et al., 2022; Kapoor & Dwivedi, 2020; Matin et al., 2012; Reisman, 2021).

2 METHODOLOGICAL PROCEDURES

To achieve the objective of identifying the main innovations adopted in the agri-food system, a systematic literature review will be carried out. This process can provide a solid basis for building theories and research reviews, which is especially necessary in the field of economics and social sciences, given the wide valorization of academic knowledge and theory. The systematic literature review allows for the analysis of previously conducted research in order to synthesize it, critically examine contributions, clarify findings, and

clarify alternative views (Rowe, 2014; Schwarz Mehta, Johnson & Chin, 2007).

The literature review is not just an overview, but a critical consolidation of the existing literature on a topic, aligned with the research objectives of the study. It allows the emergence of new theories, gaps, and research opportunities, and is the first step in the construction of new knowledge. In this study, the literature review followed five steps, namely: i) defining and framing the question; ii) identifying relevant publications; iii) quality assessment of studies; iv) synthesizing the evidence; v) interpreting the results (Botelho et al., 2011; Khan, Kunz, Kleijnen & Antes, 2003; Schwarz et al., 2007).

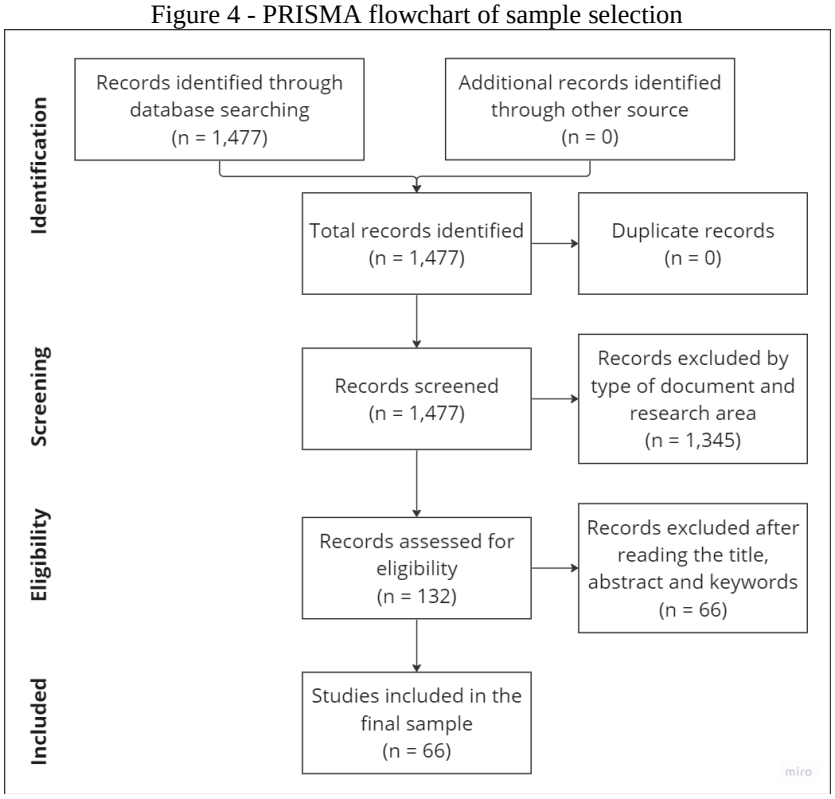
i) Delimitation and framing of the question: Despite the possibilities of competitive advantage and growth that innovations can generate for the agri-food system, organizations in the sector face many limitations, such as lack of technical knowledge about innovations, low incentives to innovate, among others. It is necessary to clarify which paths and areas of research should be considered by the organizations operating in the system as a possibility to obtain competitive advantages. Although many institutions and researchers are interested in discussing this topic, there is still much to be explored. Therefore, to achieve the objective of identifying the main innovations adopted in the agri-food system, a systematic literature review will be carried out.

ii) Identification of relevant publications: The Web of Science (WoS) database was used, as it is one of the most important research databases in the international scenario of articles published in indexed journals with Journal Citation Report (JCR) impact factor. This database also includes articles from other databases, such as Scopus and ProQuest, and has important metadata for systematic analyses, such as Journal Impact Factor, number of citations, authors, countries, abstract, among others (Carvalho et al., 2013).

The articles were selected by the terms "*innovation adoption*", *"agrifood system"*, *"agrifood sector"*, "*food industry**", "*food sector"* and "*food tech**", in the "title" field. The truncation character (*) was used to expand the possibility of searching for similar terms. This search returned a total of 1,477 records. The PRISMA guidelines - *Preferred Reporting Items for Systematic Reviews and Meta-Analysis* were used, as shown in Figure 4. First, the records were refined according to the following criteria: (i) document type, considering only records classified as "articles" and "review articles" (388 records were excluded, resulting in 1,089 records); (ii) research area, considering only those related to business, management, and social sciences (957 records were excluded, resulting in 132 records). From this refinement, the titles, abstracts, and keywords of these articles were read and analyzed to confirm their alignment with the scope of the researched topic, and

sixty-six records were eliminated because they did not deal with related topics. Thus, the final selection consisted of the remaining sixty-six records (Moher et al., 2009).

Figure 4 - PRISMA flowchart of sample selection



Source: elaborated by the author

iii) Quality assessment of studies: Unlike other types of reviews, systematic reviews require the use of specific criteria to assess the quality of the articles in the sample. Therefore, the impact factor (IF) was calculated for all sixty-six articles in the sample, as presented in Appendix A, to select the most relevant articles. The IF was calculated from the number of citations of the article in one year (C) and the impact factor of the journal in which it is published (JCR), according to Equation 1 (Bimbo et al., 2017; Carvalho et al., 2013; Littell, Corcoran & Pillai, 2008; Silveira Junior, 2018).

Equation 1 - IF Calculation

$$IF = C \times (JCR + 1)$$

Articles published in journals without JCR were discarded. After applying Equation 1, the articles were ranked in descending order according to the IF score. A Pareto analysis was then used to select 80% of articles with higher relevance, resulting in twenty-six

articles. These articles were included in the content analysis and are presented in Table 3 with their respective IFs.

Table 3 - Sample articles

	Title	Authors	Quotes 2020	JCR 2020	IF
1º	Facilitating knowledge management through filtered big data: SME competitiveness in an agri-food sector	(O'Connor & Kelly, 2017)	19	8182	155477
2º	A novel view on knowledge sharing in the agri-food sector	(Fait et al., 2019)	17	8182	139111
3º	Mobile phone adoption in agri-food sector: Are farmers in Sub-Saharan Africa connected?	(Kabbiri et al., 2017)	11	8593	94534
4º	Orchestrating innovation networks: The case of innovation brokers in the agri-food sector	(Batterink et al., 2010)	18	5149	92700
5º	An examination of product innovation in low- and medium-technology industries: Cases from the UK packaged food sector	(Trott & Simms, 2017)	9	8110	72999
6º	Many or trusted partners for eco-innovation? The influence of breadth and depth of firms' knowledge network in the food sector	(González-Moreno et al., 2019)	8	8593	68752
7º	A knowledge management approach to organizational competitive advantage: Evidence from the food sector	(Massa & Testa, 2009)	12	5075	60912
8º	A resilient social economy? Insights from the community food sector in the UK	(Sonnino & Griggs-Trevarthen, 2013)	7	5149	36050
9º	Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology?	(Matin et al., 2012)	8	3864	30920
10º	Technology transfer as a mechanism for dynamic transformation in the food sector	(Kastelli et al., 2016)	5	5783	28920
11º	Development of small and medium-sized enterprise horizontal innovation networks: UK agri-food sector study	(McAdam et al., 2014)	4	5473	21896
12º	Improving industrial R&D practices with social and ethical aspects: Aligning key performance indicators with social and ethical aspects in food technology R&D	(Flipse & Van der Sanden, et al., 2013)	2	8593	17188
13º	Evaluation and design of innovation policies in the agri-food sector: An application of multilevel self-regulating agents	(Gagliardi et al., 2013)	1	8593	8594
14º	Knowledge sources and integration ties towards innovation. A food sector perspective	(Toselli, 2016)	2	3500	7002
15º	Innovation spells in the multinational agri-food sector	(Alfranca et al., 2004)	1	6606	6607
16º	Sanitizing agri-food tech: COVID-19 and the politics of expectation	(Reisman, 2021)	1	6512	6513
17º	3D printed food attributes and their roles within the value-attitude-behavior model: Moderating effects of food neophobia and food technology neophobia	(Lee, Hwang, Kim & Cho, 2021)	1	5959	5960

18º	The role of discourse in the quest for low-carbon economic practices: A case of standard development in the food sector	(Bonnedahl & Eriksson, 2011)	1	5075	5076
19º	The challenge of introducing low-carbon industrial practices: Institutional entrepreneurship in the agri-food sector	(Stål, Bonnedahl, & Eriksson, 2013)	1	5075	5076
20º	A note on the relationship between managerial change values, innovative intentions, and innovative technology outcomes in food sector firms	(Ettlie, 1983a)	1	4272	4273
21º	The level of management maturity in the Polish food sector and its relation to financial performance	(Kafel & Sikora, 2014)	1	3824	3825
22º	Improving logistics efficiency of industrial districts: a framework and case study in the food sector	(Bottani et al., 2014)	1	3821	3822
23º	Toward solutions for food crisis in the 21st century - From basic research to development of innovative food technologies	(Mitsuda, 1999)	1	3493	3494
24º	Opening up innovation processes through contests in the food sector	(Massa & Testa, 2017)	1	3464	3465
25º	Identifying key performance indicators in food technology contract R&D	(Flipse & Van der Sanden, et al., 2013)	1	3347	3348
26º	The firm in the Information Age: organizational responses to technological change in the processed foods sector	(Cox et al., 2002)	1	3085	3086

Source: elaborated by the author

iv) Synthesizing the evidence: The articles were organized in electronic spreadsheets and analyzed according to the following variables: i) types of research; ii) research objectives. In order to obtain greater clarity in the results, content analysis was used to organize the data, as it allows the inference of knowledge related to the productions, thus identifying the main theoretical approaches related to innovation, contained in the articles of the sample (Bardin, 2004, 2016).

v) Interpreting the results: This step is described in the next topic, where the data are organized into the following categories: i) most frequent keywords; ii) types of research; iii) research objectives; iv) challenges and opportunities in the agri-food system; v) innovation in networks; vi) innovations and technologies in the agri-food system; vii) adoption of sustainable innovations.

3 ANALYSIS AND DISCUSSION

Figure 5 shows the most frequent keywords in the selected articles. The Figure was generated using the “wordcloud” function of the “wordcloud” package in R software.

Figure 5 - Word cloud of frequent keywords

Source: elaborated by the author

The most frequent words mentioned were food sector; agri-food sector; innovation management; food technology; open innovation; SMEs, which would be the equivalent of Small and Medium-Sized Enterprises - SMEs. Other keywords were mentioned to a lesser extent were food and beverage industry; network orchestration; knowledge management; ISO 9001, 9004 and 22000; sustainability; climate change; case studies.

To categorize the types of the research and research objectives, the titles, keywords, and abstracts of the twenty-six articles in the sample were read, categorized, and organized in electronic spreadsheets. Table 4 shows the codes created and the number of each category.

Table 4 - Codes used for content analysis.

Types of research		
T1	Case study	17
T2	Survey	4
T3	Documentary research	4
T4	Action research	1
Research objectives		
O1	Innovation adoption by small and medium-sized enterprises (SMEs)	8
O2	Innovation adoption in organizational business models and organizational performance	7

O3	Mapping the characteristics of food technologies	7
O4	Adoption of open innovation	5
O5	Adoption of sustainable innovations (eco-innovation)	5
O6	Innovation adoption for a specific technology	3
O7	Barriers and facilitators affecting innovation adoption	2
O8	Effects of innovation policies	2

Source: elaborated by the author

To proceed with the content analysis, the twenty-six articles in the sample were read in full, which made it possible to identify the main theoretical approaches present in the articles and their frequency, i.e.: Challenges and opportunities in the agri-food system; Innovation in networks; Innovations and technologies in the agri-food system; Adoption of sustainable innovation, as shown in Table 5.

Table 5 - Main theoretical approaches

Theoretical Approach	Frequency
Challenges and opportunities in the agri-food system	(57,69%)
Innovation in networks	(38,46%)
Innovations and technologies in the agri-food system	(34,61%)
Adoption of sustainable innovation	(15,38%)

Source: elaborated by the author

The in-depth reading allowed the review of theoretical contributions on the innovation adoption in the agri-food system, related to each of the theoretical approaches identified. These are presented below.

3.1 Challenges and opportunities in the agri-food system

Fifteen articles in the sample address challenges and opportunities in the agri-food system, indicating the relevance of the topic in the agri-food system literature. The main challenges are related to climate change, pressures on the global food supply, demands for sustainability, traceability, and transparency, rising food prices and the spread of food-borne diseases. Growing concern about these issues has led to a new food equation in which the agri-food system is a fundamental part, as gas emissions from the agri-food system exceed the targets set by the Paris Agreement, which aims to reduce global warming and greenhouse gas emissions (Bryant & Van der Weele, 2021; González-Moreno et al., 2019;

Morgan & Sonnino, 2010; Sonnino & Griggs-Trevarthen, 2013).

From a public health perspective, some diseases such as obesity, heart disease, some cancers, high cholesterol, and blood pressure are linked to meat consumption. Approximately two billion people are food insecure, meaning they lack micronutrients and vitamins, which can lead to impaired cognitive and physical abilities. There is also evidence that the overuse of antibiotics in livestock can lead to antibiotic resistance, creating a fertile environment for the propagation and spread of disease and pandemic outbreaks (Bryant & Van der Weele, 2021; Morgan & Sonnino, 2010).

Local farming practices and the community food sector, which includes cooperative initiatives, farmers' markets, and community agriculture, have been touted as a more sustainable alternative to the conventional global agri-food system. Reducing meat consumption is also identified in environmental plans and international reports as fundamental to preserving the planet's biodiversity (Bryant & Van der Weele, 2021; Sonnino & Griggs-Trevarthen, 2013).

In addition, rapid technological change has transformed the agri-food system, which has traditionally been technologically backward and lacking in cooperation. These conditions generate volatility and greater complexity, as well as the need for greater control over the entire value chain. Despite the intimidation it can cause, rapid technological change also leads to advantages for the agri-food system, such as the emergence of new ICT, standardization of processes, lower logistics and transport costs, and greater coordination between members of the value chain. For these benefits to be present in organizations, the process of innovation adoption, which is the focus of this, must occur (Fait et al., 2019; Kabbiri et al., 2017).

Two articles deal with the innovation adoption in the agri-food system, one at the individual level and the other at the organizational level. From the individual point of view, models have been developed to measure the behavioral intention to adopt technologies, such as the Technology Acceptance Model - TAM, which considers perceived usefulness and perceived ease of use as key factors for adoption. After studies in the agri-food system, the authors add to this model the constructs of perceived advantage and socioeconomic characteristics as factors influencing individual innovation adoption (Chuttur, 2009; Kabbiri et al., 2017).

At the organizational level, the aspect studied relates to the influence of managers and the development of the skills they develop to identify and support innovation within organizations. The occurrence of innovation and creativity episodes was related to the

presence of human resources dedicated exclusively to innovation processes, and it was found that the size of the organization does not influence the adoption. It is worth mentioning that this is the oldest article in the sample, published in 1983 (Ettlie, 1983a).

3.2 Innovation in networks

Ten articles in the sample address the importance of networking for innovation adoption processes. It can be affirmed that firms in the agri-food system with networking capabilities have a greater capacity for innovation than others. Policy makers in the European Union encourage inter-organizational cooperation as a strategy to generate innovation in their economies. Innovative organizations have incorporated external perspectives and ideas into their R&D processes, and it has been found that for many companies it is not feasible to rely solely on innovations generated by internal activities. In many of them, there is a low capacity to invest in R&D and to face the risks that this investment would entail, which means that R&D activities, when present, are informal. Technology transfer mechanisms allow technological advances in other sectors to be adapted and used by organizations in the agri-food system, generating a series of benefits related to the innovation adoption. In addition, the exchange of experiences, the interaction between companies, the creation of inter-organizational networks and the maintenance of networks are ways of overcoming the challenges faced by organizations (Batterink et al., 2010; Bottani et al., 2014; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Kastelli et al., 2016; Trott & Simms, 2017).

Network collaboration reduces the distance between companies that have a need and those that already have specific solutions and can share them, which is an important external ingredient in the innovation adoption process. Since the traditional innovation model alone does not serve all organizations, joint product development and the adoption of open innovation, in which external and internal sources of knowledge are used, are ways to increase competitiveness (Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; McAdam et al., 2014; Trott & Simms, 2017).

There is a growing relationship between networking and ICT adoption, given the inherent characteristics of the knowledge age. Organizational innovation processes are closely related to knowledge management. Incremental innovation relies on the knowledge that organizations have accumulated over the years, while radical innovation is supported by newly acquired knowledge. For example, access to ICT, such as big data and others, can support data management and information flow, thereby strengthening the organization's

networked innovation processes (Cox et al., 2002; Massa & Testa, 2017; O'Connor & Kelly, 2017).

3.3 Innovations and technologies in the agri-food system

The sample includes nine articles that address specific innovations and technologies developed in the agri-food system. These are related to the adoption of ICT (Kabbiri et al., 2017; O'Connor & Kelly, 2017), innovations in food packaging (Matin et al., 2012; Trott & Simms, 2017), nanotechnology (Flipse & Van der Sanden, et al., 2013; Matin et al., 2012), food created by 3D printing (Lee et al., 2021) and new methods of food preservation (Mitsuda, 1999).

Innovations emerge from the identification of problems and needs, and those that promote alternatives to the sustainability and environmental challenges are considered the most attractive nowadays. These innovations are responsible for the rush of investors and the creation of the agtech and foodtech sectors, which, although global, have as their main center of investment and entrepreneurial activity the United States and California. An effective example of innovation adoption in the agri-food system, presented in two articles of the sample, are the technologies used for the production of a new product named alternative proteins. This product are produced from plants, vegetables, algae or even produced in vitro from stem cell culture extracted from animals. Compared to traditional animal agriculture, these technologies can reduce greenhouse gas emissions by up to 96%, reduce land and water requirements for animal agriculture by up to 99% and 96% respectively, and offer greater food safety and purity since they are developed in the laboratory (Lee et al., 2021; Reisman, 2021).

When a new product is introduced to the market, it is necessary to understand how consumers will react to it. When it comes to food, the refusal, fear, or avoidance of eating new foods is called food neophobia, a topic addressed in two articles in the sample. Neophobia can occur for new foods and also for the use of new technologies used in their production, such as nanotechnology. A tool has been developed to measure the level of food technology neophobia, the Food Technology Neophobia Scale - FTNS. This scale can be important in predicting the level of acceptance of new foods and whether they will be successful in the marketplace (Cox & Evans, 2008; Lee et al., 2021; Matin et al., 2012).

In addition, a study of the sample regarding the temporal pattern of innovations revealed that the companies that drive technological change in the agri-food system are

those with persistent innovators, who invest in innovation over long periods of time and not just occasionally and once. This finding is in line with the study that states that the adoption of innovation is related to the presence of human resources dedicated exclusively to innovation processes (Alfranca et al., 2004; Ettlie, 1983a).

3.4 Adoption of sustainable innovations

Four articles in the sample deal with the adoption of sustainable innovations. The presence of this topic may be related to the fact that the agri-food system has a close relationship with the primary sector and is highly dependent on natural resources. The use of these resources by organizations and agricultural practices can be sustainable or indiscriminate, and given that the planet's environmental limits have already been exceeded or are in a critical situation due to factors such as biodiversity loss and climate change, indiscriminate use has been shown to be a practice present in the agri-food system (González-Moreno et al., 2019; Stål, Bonnedahl, & Eriksson, 2013).

Innovations and technologies can be used to produce food with less water and fertilizer, and with lower emissions of pollutants such as carbon monoxide and carbon dioxide. These innovations can be used in primary food production, processed food production, packaging and product distribution. Organizations that choose to adopt sustainable innovations do so because of regulatory requirements or voluntarily in search of new customer segments, or to obtain certifications related to the quality and sustainability of internal processes and food safety, such as ISO - International Organization for Standardization. For sustainable innovations to be widely adopted in organizations, it is necessary to share knowledge about the topic, its possibilities and the reasons that justify its adoption, both internally and externally. Building long-term and trusting relationships with stakeholders can help to maintain and develop sustainable innovations (Bonnedahl & Eriksson, 2011; González-Moreno et al., 2019; Horbach, Rammer & Rennings, 2012; Kafel & Sikora, 2014; Matin et al., 2012; Stål, Bonnedahl, & Eriksson, 2013).

3.5 Thematic Gaps and Proposed Research Directions

From the systematic literature review, thematic gaps were identified, as shown in Table 6, which can direct future research on the topic, in addition to allowing the study not to end at the stage of consolidating existing research. Although not an essential step in a systematic review, future research directions can increase the added value of the study and

do not require a detailed implementation plan, but rather a reasoned proposal (Rowe, 2014; Schryen, 2013).

Table 6 - Thematic gaps and future research directions

Gap	Articles	Future research directions
Innovation identified in the agri-food system that requires in-depth research: alternative proteins	(Lee et al., 2021; Reisman, 2021)	Investigate how the adoption of alternative proteins by organizations in the agri-food system will occur.
Innovation possibilities for SMEs in the agri-food system	(Batterink et al., 2010; Kastelli et al., 2016; McAdam et al., 2014; Trott & Simms, 2017)	Proposing open innovation models for SMEs in the agri-food system
Studies conducted with small samples or brief time periods	(Batterink et al., 2010; Bottani et al., 2014; Fait et al., 2019; Flipse & Van der Sanden, et al., 2013; Gagliardi et al., 2013; González-Moreno et al., 2019; Kabbiri et al., 2017; Kafel & Sikora, 2014; Massa & Testa, 2017; Matin et al., 2012; McAdam et al., 2014; O'Connor & Kelly, 2017; Sonnino & Griggs-Trevarthen, 2013; Trott & Simms, 2017)	Application across different sectors, contexts, and user groups so that findings and discussions are expanded.

Source: elaborated by the author

The research agenda that emerged from this analysis was developed along three lines of inquiry. One of the innovations in the agri-food system identified among the articles in the sample is alternative proteins. Since new products can change the market and given the importance of meat in the agri-food system, exploring this topic in more depth is a relevant direction for research. Does this innovation represent a threat to companies already operating in the agri-food system? Or will these companies adopt the innovation by beginning to alternative proteins? (Lee et al., 2021; Reisman, 2021; Schumpeter, 1985).

Given the assertion that innovation in its traditional model and investment in R&D do not apply to the reality of SMEs in the agri-food system, and that the adoption of open innovation and joint product development are the paths to innovation, how can this adoption be operationalized? Do SMEs know how to do it? A study proposing models for the adoption of open innovation in SMEs is an interesting way forward (Batterink et al., 2010; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Kastelli et al., 2016; McAdam et al., 2014; Trott & Simms, 2017).

Suggestions for the future in the sample articles are mostly focused on methodological aspects. Sixteen articles note that studies have been conducted with small groups, small samples, or brief time periods, and suggest that future studies should be applied to different sectors, contexts, and user groups so that findings and discussions are

broadened and do not limit generalization.

4 CONCLUSION

The innovation adoption has been studied by different researchers at distinct levels of analysis. From this study, it was possible to review the literature on the adoption of innovations in the agri-food system, to synthesize the knowledge on this topic and to identify biases and knowledge gaps in the existing literature, as suggested by the literature (Rowe, 2014). The objective of identifying the main innovations adopted in the agri-food system was achieved, indicating which pathways and areas of research should be considered by organizations as a possibility to gain competitive advantage.

Innovations and technologies are related to the use of ICTs in the management, production, processing, distribution and services involved in the agri-food system, enabling innovations in packaging, preservation methods and the use of nanotechnology and 3D printers for food design and printing. It should be noted that innovations that promote alternatives to sustainability challenges are considered the currently most attractive and are responsible for a global rush of investors in the agtech and foodtech sectors. The adoption of sustainable innovations is an opportunity for the agri-food system, given the close relationship with the primary sector and the high dependence on natural resource. Sustainable innovations allow, among other things, food production with less water and fertilizer use, as well as low emissions of pollutants.

It was possible to identify the key processes that can reduce the bottleneck in the innovation adoption in the agri-food system. These are: creation and cooperation in networks; interaction between companies; exchange of experiences; maintenance of networks. These processes promote network innovation, reduce the distance between companies seeking for solutions and those that already have them and collaborate in R&D processes. The study also identified the main challenges facing the agri-food system, which it is important to reinforce. They are: climate change; pressures related to global food supply; demands for sustainability, traceability and transparency; food price increases; spread of food pathologies; rapid technological changes in the agri-food system, traditionally considered technologically backward. Innovations arise from the identification of problems and needs, so it is not surprising that most of the innovations identified in the study are related to the challenges faced as a way of addressing them.

Given the economic importance of the agri-food system for the country, the results

of the study are fruitful from both a practical and theoretical point of view. The contemporary innovations and challenges presented can be useful for managers of organizations, industries of the agri-food system and other actors involved, as well as for public policy makers in promoting and encouraging the adoption of innovations that can intensify the competitiveness of the system. From a theoretical point of view, it contributes to the strengthening of studies related to the theory of innovation adoption, bringing together different perspectives on the subject, and identified important thematic gaps, as alternative proteins adoption by agri-food system organizations and innovation possibilities for agri-food SMEs.

Although the results of this study are interesting and useful, it has limitations that need to be pointed out. Innovation and its adoption process are complex constructs and it would be impractical to capture all of its particularities through this study (Damanpour & Schneider, 2006). In addition, the results are based on the analysis of twenty-six articles. Future studies with larger samples may provide new contributions.

ARTICLE 2 - Innovation Adoption in the Agri-food System: the influence of perceived innovation characteristics

SUMMARY

The innovation adoption can be influenced by different perceived characteristics of innovation, which vary from sector to sector. The agri-food system is an extremely important sector that has undergone several transformations due to its responsibility to feed a rapidly growing population while facing climate change and resource scarcity. This challenge presents the sector with the possibility of various innovations. However, for the adoption of innovations to occur efficiently, it is necessary to identify the perceived characteristics of innovations that may influence innovation adoption, which is the objective of this study. For this purpose, semi-structured interviews were conducted with managers involved in the adoption of innovations in the agri-food system. It was possible to verify that the following characteristics influence the adoption of innovations in the agri-food system: Compatibility and Market Demand, Relative or Economic Advantage, Complexity, Testability, Visibility and Uncertainty.

Keywords: Perceived innovation characteristics; Innovation adoption; Agri-food system.

1 INTRODUCTION

The agri-food system is a major contributor to national economies and has the important mission of feeding an ever-growing population. . The sector faces growing challenges due to its dependence on natural resources and also the negative impact it can have on the environment. These issues have been addressed through the adoption of technologies and innovations that are developed for the benefit of the sector and for organizations to remain up-to-date and competitive. In this context, the innovation adoption occurs when an organization decides to start using an innovation, which can be in the form of a new product, service, process, system, equipment or even a new policy, whether generated internally or acquired externally by the organization (Daft, 1978; Davis, 1989; Rogers, 2003; Teklu, Simane & Bezabih, 2023; Timpanaro et al., 2023).

Studies that analyze the innovation adoption define the existence of certain perceived innovation characteristics that can influence the attitude towards an innovation and the propensity of members of an organization to adopt an innovation. However, there are few studies that analyze these dimensions from the perspective of the agri-food system, its specificities, challenges and current reality (Fait et al., 2019; Frambach & Schillewaert, 2002; Kabbiri et al., 2017; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Rogers,

2003).

An innovation in the agri-food system that has been adopted by major food producers around the world is alternative protein, a protein source that are not derived from animals, but from plants, vegetables, insects and other non-conventional sources. It is necessary to analyze how the large agri-food industries in Brazil will behave in the face of this innovation in the sector, so alternative proteins were chosen as the object study for this article (Bryant & Van der Weele, 2021; Guan et al., 2021).

Given these considerations, the main objective of this article is to identify the perceived characteristics of innovation that may influence innovation adoption. The specific objectives are: To identify the perceived characteristics of the innovation that are relevant to the Brazilian agri-food system; to identify the influence of the perceived characteristics in the process of innovation adoption in the agri-food system. To this end, a study was carried out with 29 managers and leaders involved in the process of adopting alternative proteins, in which semi-structured interviews were used. The data was analyzed using content analysis technique, divided into two types: frequency and thematic (Bardin, 2004, 2016; Minayo, 2014).

It is possible to affirm that this article presents theoretical and practical contributions. It enriches the literature by presenting data sources that consider the agri-food system and the Brazilian context, besides verifying which perceived characteristics of innovation have influence with the agri-food system and which do not. In terms of practical contributions, the article raises considerations for managers who make decisions about the adoption of innovation, pointing out which variables are increasingly used, which are not, and which should receive more attention.

This article is structured in four sections, besides this introduction. In the next section, the theoretical framework is addressed in the following topics: (i) organizational innovation adoption; (ii) perceived innovation characteristics. Following are the methodological procedures and the results and discussions. Finally, the final considerations including limitations and proposals for future studies.

2 THEORETICAL REFERENCE

To achieve the article's objective of identify the perceived innovation characteristics that may influence the innovation adoption, it is necessary to understand the organizational innovation adoption process and to identify the perceived innovation characteristics that

have synergy with the agri-food system and can influence the alternative proteins adoption.

2.1 Organizational Innovation Adoption

Some organizations concentrate their efforts on satisfying the current wishes of traditional customers and thus end up neglecting possibilities for new attributes. It happens that this set of attributes is evolving increasingly faster, and the life cycle of products and technologies is getting shorter, making room for emerging technologies and innovations. In this context, organizations that remain competitive are those that are constantly adopting recent technologies and creating new products and services that meet consumer expectations. For this purpose, the identification of factors that influence the adoptions and/or rejections of innovations has become fundamental to organizations and also to academia (Bower & Christensen, 1995; Chesbrough, 2007; Makkonen, Johnston & Javalgi, 2016; Marôcco et al., 2014; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Pereira, Imbrizi, Freitas & Alvarenga, 2015; Ploll, Arato, Börner & Hartmann, 2022; Timpanaro et al., 2023).

The concept of innovation adoption is related to the decision of any individual or organization to use or not use an innovation. Adoption can occur both at the individual level and at the organizational level, which is the focus of this study. The organizational innovation adoption occur through the adoption of new products, services, processes, programs, systems, equipment and/or politics, whether they are generated internally or acquired externally, and it can lead to industry's productivity, greater efficiency of the organizations and also keep it up to date with market changes (Daft, 1978; Damanpour & Gopalakrishnan, 1998; Davis, 1989; Rogers, 2003; Singh et al., 2023).

2.2 Perceived Innovation Characteristics

Everett M. Rogers is considered a central researcher about the adoption process and his innovation diffusion theory seeks to clarify the adoption process by identifying five innovation characteristics perceived by individuals, or dimensions, that can influence the attitude towards an innovation and the propensity of members of an organization to adopt a new product, as detailed in the topics below (Frambach & Schillewaert, 2002; Rogers, 2003).

2.2.1 Relative Advantage

Relative Advantage is the degree to which an innovation is considered better than the idea being replaced, whether in economic terms, convenience, satisfaction and/or social prestige. This dimension is also termed as perceived benefits or perceived usefulness in some studies and other factors were analyzed under the scope of this dimension such as quality, convenience, performance, and usefulness. Studies state that this dimension is the main driver for innovation adoption in the agri-food system and in other areas too. As with consumers, those involved in the agri-food chain may present subjective preferences and perceptions for the attributes of the innovation. Benefits of innovations to food security, possibilities for climate change adaptation and mitigation, are a few among many examples of factors that influence the innovation adoption (Aamir et al., 2023; Meshesha, Birhanu & Ayele, 2022; Montes de Oca Munguia, Pannell & Llewellyn, 2021; Rogers, 2003; Teklu, Simane & Bezabih, 2023).

2.2.2 Compatibility and Market Demand

Compatibility is related to the degree to which an innovation is seen as consistent with potential adopters' existing values, past experiences and needs. When assessing the use of an innovation in the organizational aspect and its adoption rate, the Compatibility dimension is a key factor. The adoption of innovation is not a one-time event, but a process of additions to current technologies and processes of companies, accumulation, and integration of knowledge. These process additions must be compatible with existing processes and routines (Silva et al., 2023; Rogers, 2003).

It also considers how much the innovation is aligned with the existing versions of a particular innovation, its practices, and values, being more likely to adopt innovations that are compatible and adaptable to the characteristics, processes, and values of the organization. In this respect, some important characteristics can be considered when assessing the level of compatibility in the adoption of an innovation, such as invariability of existing data, possibility of process integration and the need not to change suppliers, for example (Aamir et al., 2023; Rogers, 2003).

2.2.3 Complexity

Complexity is the dimension related to how much adopters perceive the innovation as something difficult to understand, adopt and/or use and the perceived risks in adoption and usually has a negative effect, as the more complex the innovation, the less chance it has of being adopted. In the organizational context, complex innovations require a level of tacit knowledge on the part of employees that demands efforts both for understanding and adoption. Thus, this is a dimension that has a negative influence on adoption, since the higher the degree of complexity, the lower the adoption rate of the innovation will be (Aamir et al., 2023; AlBar & Hoque, 2019; Silva et al., 2023; Rogers, 2003).

2.2.4 Testability

Testability is related to the experiments and tests with the innovation that can be accomplished, even with a limited authority or expertise, and refers to the degree to which the potential adopter considers that it is possible to try the innovation, even with some limitations. This dimension is also named as Trialability and adequate attention needs to be addressed to it, as the knowledge and skill set of a given innovation may vary significantly among adopters (Aamir et al., 2023; Iskender, Sirakaya-Turk, Cardenas & Hikmet, 2022; Rogers, 2003).

2.2.5 Visibility

The dimension Visibility, also named as Observability, is the characteristic related to how visible the innovation results are and refers to the degree to which an innovation can deliver measurable and tangible results for an organization and also the level to which it is possible to visualize the benefits and gains after the innovation adoption (Aamir et al., 2023; Rogers, 2003).

2.2.6 Uncertainty

To the characteristics proposed by Rogers, some authors have added a relevant dimension that is the Uncertainty. This is related to the degree of technical, financial and/or social uncertainty in adopting alternative proteins production. Adopting an innovation involves uncertainties such as what barriers may arise during adoption, whether the firm

will be able to adapt to the innovation, whether the costs involved will yield positive results, and so on. For more mature innovations, where there is more information or more experts, the uncertainty may be less, but it still exists (Frambach & Schillewaert, 2002; Nooteboom, 1989).

2.3 Perceived Innovation Characteristics by Other Authors

Other studies added important perceived innovation characteristics to those initially proposed by Rogers (2003), as presented in Table 7. Tornatzky and Klein (1982), despite proposing twenty-five new dimensions, concluded that the characteristics that are most related to innovation adoption are part of the five characteristics initially proposed by Rogers (2003). Nevertheless, the study provides important insights into new dimensions that can influence adoption, as Cost, which is related to the costs to implement the innovation and is negatively related to the adoption. The more expensive the innovation, the less quickly it will be adopted. Other important characteristics is Profitability, related to the level of profit that the adoption can provide (Aamir et al., 2023; Tornatzky & Klein, 1982).

Table 7 - Perceived innovation characteristics

Author	Characteristics
Rogers (2003)	Compatibility; Relative Advantage; Complexity; Testability or Possibility of Experimentation; Visibility.
Tornatzky and Klein (1982)	Association with major enterprise; Clarity of results; Communicability; Continuing cost; Cost; Divisibility; Ease of operation; Flexibility; Importance; Initial cost; Mechanical attraction; Observability; Payoff; Pervasiveness; Profitability; Radicalness; Rate of cost recovery; Regularity of reward; Reliability; Riskiness; Specificity of evaluation; Saving of discomfort; Saving of time; Scientific status; Social approval.
Moore and Benbasat, (1991) and	Image; Volunteering; Results report.
Venkatesh, Thong, and Xu (2012)	Hedonic motivation; Price value; Experience and habit.

Source: Adapted from Moore and Benbasat (1991), Rogers (2003), Tornatzky and Klein (1982), and Venkatesh, Thong, and Xu (2012).

As for the characteristics proposed by Moore and Benbasat (1991), Image refers to how much the use of an innovation improves the social status of the adopter. This characteristic is remarkably similar to Observability that represents how much the results of an innovation are visible to others, and Social Approval, related to the status gained in adopting the innovation, both proposed by Tornatzky and Klein (1982). The characteristic

Volunteering is related to the degree to which the use of an innovation was carried out voluntarily by the adopter and Results Report to how tangible are the results generated by an innovation (Moore & Benbasat, 1991; Tornatzky & Klein, 1982).

Venkatesh, Thong, and Xu (2012) proposed the characteristic Hedonic Motivation, which is related to the fun or pleasure derived from adopting the innovation. Price Value represents the difference between the perceived benefit and the monetary cost of using the innovation and is considered positive when the benefits of use are greater than the cost. As for Experience and Habit, experience refers to the opportunity to use innovation, while habit represents the degree to which individuals tend to perform behaviors automatically due to learning (Aamir et al., 2023; Venkatesh, Thong, and Xu, 2012).

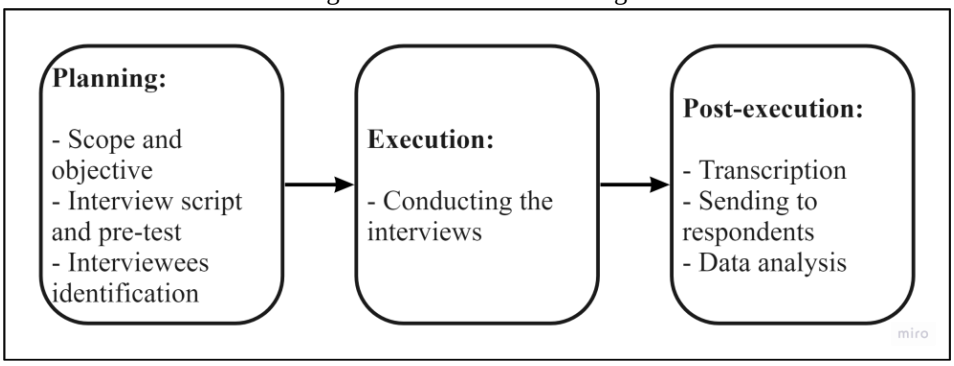
3 METHODOLOGY

An incursion into the field of investigation was carried out, based on primary data collected from semi-structured interviews with managers and leaders who are involved in the process of adopting alternative proteins in the agri-food system in Brazil. The interview is a qualitative data collection technique that allows the interviewer to have access to the interviewee's perspectives, experiences, feelings, opinions, thoughts and intentions, that would not be available through observation only (Eisenhardt, 2021; Eisenhardt & Graebner, 2007; Langley & Abdallah, 2011; Patton, 2002).

Semi-structured interviews are characterized by the interviewer's freedom to conduct the topic and combine open and closed questions. It starts with a set of questions defined in advance and during the interview, according to its progress, questions can be added or removed, and the interviewee can answer questions. The interview script is used as a guide to the topics that need to be covered and the standardized questions that will be asked to all interviewees so that the answers can be compared in the data analysis stage. The Snowball Sample technique was used to identify the interviewed individuals, reaching a total of 29 respondents (Boni & Quaresma, 2005; Handcock & Gile, 2011; Lune & Berg, 2017; Patton, 2002).

The interviewees have strategic positions within the organizations, including directors, managers, coordinators, supervisors, and specialists, and have an average of 5 years working in the organization. The identification of each respondent, as well as their position in the organization and the length of time they have worked in the organization is described in Appendix F.

Figure 6 - Data collection stages



Source: elaborated by the author

The data collection process through the interviews was conducted in three stages: planning, execution, and post-execution, as shown in Figure 6. At the planning stage, the following steps were followed:

1) Definition of the project scope and research objective: based on the literature survey, six perceived innovation characteristics that are related to the agri-food system and are relate to each other were identified to be analyzed, as presented at Table 8.

Table 8 - Dimensions proposed

Dimensions	Description	Reference
1. Perceived innovation characteristics		
1.1 Compatibility and market demand	Degree to which alternative proteins are seen as consistent with potential consumers' existing values, past experiences and needs, and tendency of consumers' to adopt alternative proteins.	(Frambach & Schillewaert, 2002; Kabbiri et al., 2017; Rogers, 2003; Tornatzky & Klein, 1982; Venkatesh, Thong, and Xu, 2012)
1.2 Relative or economic advantage	Degree to which organization considers alternative proteins better than the conventional meat, whether in economic terms, convenience, satisfaction and/or social prestige.	(Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.3 Complexity	How difficult is to members of the organization to understand how the system to produce alternative proteins works and how to use it.	(Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.4 Testability	Degree to which the system to produce alternative proteins has been tested (even on a limited scale) by the organization; or suppliers communication is able to demonstrate the functionality of the system, create awareness and influence potential organizations' perceptions.	(Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky, Fleischer & Chakrabarti., 1990; Tornatzky & Klein, 1982)
1.5 Visibility	How visible to the organization are the results of adopting alternative proteins.	(Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.6 Uncertainty	Degree of technical, financial and/or social uncertainty in adopting alternative proteins.	(Frambach & Schillewaert, 2002; Nooteboom, 1989)

Source: elaborated by the author

2) Construction of the interview script: a preliminary outline of the script was prepared based on the objectives of the study. A table has been created linking each dimension with the questions that allow the dimension to be investigated during the interview, as presented in Appendix C. Three expert evaluators, with extensive experience in research, academic and market experience in the field of innovation were contacted and assisted in the construction of the interview script. Furthermore, two PhD researchers carried out the pre-test of the instrument, in January 2023. The revision suggestions referred to the addition of questions related to the identification of the interviewee and one question about the company's main activities. The final interview script, after the revision, is presented in Appendix B.
3) Identification of the interviewees: the capture of the participants of the sample was done on purpose, where each respondent is chosen in order to maximize the marginal value of the information obtained. In order obtain access to managers and leadership positions active in the process of alternative proteins adoption, the Snowball Sample technique was used (Handcock & Gile, 2011; Langley & Abdallah, 2011; Patton, 2002).

All twenty-nine interviews were conducted by video calls, between January and March of 2023, and had an average duration of 40 minutes. At the beginning of all interviews, the following information was given to the interviewee: the objectives of the study; what will be done with the search results; how respondents were selected; confidentiality of the responses of each interviewee; request for permission to recording; presentation and signature of the Consent Form, presented in Appendix G; clarification of possible doubts.

In the interviews post-execution, the following steps were carried out:

1) Transcription of the interviews using the free web application "oTranscribe."
2) Sending transcripts to interviewees, so that they can confirm the content expressed during the interviews. When necessary, adjustments can be made to the transcripts according to the interviewees' appointment, but in this study it was not necessary (Langley & Abdallah, 2011; Lincoln & Guba, 1985).

The data collected during the interviews were analyzed through content analysis technique, which uses systematic and objective procedures to analyze the messages passed by the interviewees. Frequency analysis was used, with a mixed grid in which categories are defined in a preliminary way from the literature (closed grid), but categories that emerge

from the field were also admitted. The thematic analysis method was also used, in order to identify meaning nucleus on certain topics in the interviewees' answers (Bardin, 2004, 2016; Minayo, 2014).

4 RESULTS AND DISCUSSION

The analysis of the collected data with managers and leaders who are involved in the process of alternative proteins adoption allowed a better understanding of the perceived innovation characteristics that may influence the innovation adoption. The topic below presents a deepening of the interviewees' vision in relation to the perceived innovation characteristics. Interviewees will be identified as I (interviewee) plus the interview number.

4.1 Compatibility and Market Demand

Compatibility and Market Demand is the dimension related to the degree to which alternative proteins are seen as consistent with potential consumers' existing values, past experiences and needs and tendency of consumers' to adopt alternative proteins (Frambach & Schillewaert, 2002; Kabbiri et al., 2017; Rogers, 2003; Tornatzky & Klein, 1982; Venkatesh, Thong, and Xu, 2012).

Table 9 - Perception about the alternative proteins market

Category	No. of responses	Frequency
Future growth in the alternative proteins market	12	41%
Moment of stagnation	10	34%
Many barriers to enter the market	6	21%

Source: elaborated by the author

Regarding how they see the future market perspectives and the trends in the adoption of alternative proteins, it was verified that the majority of interviewees see a perspective of growth in the market of alternative proteins in the next years, as presented in Table 9. Despite this, many also believe that the result obtained by companies operating in the segment has not kept up with expectations and that the current moment is one of stagnation. I8 comments that *"at a certain moment there was an overvaluation of the potential"*, while I9 reinforces that *"the industries invested and believed a lot in this, and the consumer did not come at the same pace. We are now in a process of reaccommodation."* For some interviewees, alternative proteins have encountered barriers

when coming to market, such as nutritional, taste and experimentability issues. I27 says that there are *"many people placing alternative proteins next to an ultra-processed basket, which would be even worse than meat consumption"*, while I24 mentions that it is *"necessary to technologically develop (the segment) to deliver a good product nutritionally, in delivering flavor, texture, as well as in the accessibility of these products, which today is a major barrier"*. I25 commented on the expectation regarding the arrival of the cultivated meat in the market: *"we hope that when the cultivated meat becomes a product that actually arrives in the market, in 2040 to 2050 it will gain around 20% to 30% of marketing share"*.

Table 10 - Company's experience with the adoption

Category	No. of responses	Frequency
Need strategy, communication, and positioning adjustments	14	48%
Not good	8	28%
Lack of technology in Brazil	7	24%
Good	2	7%

Source: elaborated by the author

Regarding how the company's experience with the adoption of alternative proteins has been so far, none of the respondents was very enthusiastic about the results, as presented in Table 10. Only two interviewees described the experience as *"good"* so far. Somewhere dissatisfied and words like *"frustrating"*, *"ok"*, *"incipient"* were used to describe the experience, and most of the interviewees affirmed the need for adjustments in the definition of strategy, communication, and positioning. I21 states, *"It is a challenge to get the communication and positioning right, because it is a different consumer. All the history we have had was with a consumer we knew very well. So, we invested a lot in these last two, three years in research with these new consumers, and it was even difficult to select them, because who are you going to talk to? With vegans, with vegetarians?"* This need for adjustments to existing processes is cited in the literature as something that influences the innovation adoption, since the adoption is not a one-time event, but a process of additions to current technologies and processes of companies, accumulation, and integration of knowledge. The reports demonstrate that the new processes may not have been carried out in the best way, negatively impacting the adoption of alternative proteins (Silva et al., 2023; Rogers, 2003).

Some interviewees cited that the lack of technology in Brazil brought the need to enter the market via international partnerships, which greatly increased the cost of products, making them unattractive to consumers, as can be seen in the speech of I16: *"The price*

index tends to work about 120%, 130% above animal protein. It is a protein that is still expensive because of the partnerships, a lot of things come imported, and a lot of technology is still not available in Brazil."

4.2 Relative or Economic Advantage

The dimension Relative or Economic Advantage is related with the degree to which organization considers alternative proteins better than the conventional meat, whether in economic terms, convenience, satisfaction and/or social prestige (Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982).

Table 11 - Benefits and advantages in the adoption

Category	No. of responses	Frequency
Values and brand positioning	13	45%
No benefits and advantages in economic terms	10	34%
Competitiveness	9	31%
New customers and markets	6	21%

Source: elaborated by the author

For the majority of interviewees, the adoption of alternative proteins was beneficial to reinforce the values and positioning of the brand, and brought benefits related to social prestige, as presented in Table 11. For many respondents, the adoption brought advantages in relation to staying competitive with competitors, who were also adopting alternative proteins. In addition, interviewees also mentioned that the adoption allowed them to reach new customers and markets, as mentioned by I24: alternative proteins *"came in as a portfolio composition, so that we can serve different markets, have a portfolio for different customers and different audiences and needs"*.

It is important to note that many interviewees stated that there were no benefits and advantages in economic terms. This statement adds to the analysis of the previous dimension, Compatibility and Market Demand, where the interviewees explained about the increase in costs due to the need to enter the market via international partnerships. This corroborates the statement of Tornatzky and Klein, that the costs needed to implement the innovation are negatively related to the adoption and the more expensive the innovation is, the less quickly it will be adopted (Tornatzky & Klein, 1982).

Regarding any disadvantage that the adoption of alternative proteins may have brought to the company, the majority said there were no disadvantages. On the other hand, some consider that the disadvantage was in relation to the financial aspects, as a financial

investment was made and there was not the expected return. I16 states, *"It is expensive. It is not cheap to develop alternative protein. That is what prevents the advance... the company cannot pass 100% of the cost to the consumer, because the consumer is not willing to pay all this, as well. So, that reduces the portfolio"*.

4.3 Complexity

Complexity is the dimension related to how difficult is to members of the organization to understand how the system to produce alternative proteins works and how to use it (Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982).

Table 12 - Complexity to adopt alternative proteins.

Category	No. of responses	Frequency
Totally different production process	8	28%
New market and new brand positioning	8	28%
Search for new suppliers and partners	7	24%
Production methods and operational solutions	5	17%
Product development and technical formulations	5	17%
Regulations and legislation	3	10%
Employees conviction	3	10%

Source: elaborated by the author

Some of the interviewees stated that the production of alternative proteins is a quite different production from what was already done by the company and the chain already established, as presented in Table 12. The main aspects of Complexity cited were the complexity of understanding a new market and new brand positioning and the search for new suppliers and partners. I21 affirmed, *"We started this entry into the market by visiting some factories in Europe and selecting one that brought us greater security and product performance. Then we adapted it, increased it to our form and adapted it to the availability they had there."* I8 confirms the dependence on partnerships when he says, *"we didn't even have the best technical, operational solution. So, sometimes, I don't have a suitable extruder, a suitable mixer (referring to equipment that is used in the production process of alternative proteins), so I have to get in touch, identify the players that can help us."* I28 corroborates these statements saying, "*The most complex part is left to the partner company*". The reports confirm what the literature presents in relation to the dimension Complexity. As the innovation is perceived as something difficult to understand and adopt, the innovation adoption is negatively impacted and it is necessary to seek support from

partners who can effectively make the adoption happen (Aamir et al., 2023; AlBar & Hoque, 2019).

Other aspects of Complexity were also mentioned less frequently, as: understanding the production methods and developing operational solutions; product development and new technical formulations; understanding regulations and legislation; convincing the employees that alternative proteins are feasible. It is worth mentioning the statement of I25: *"it is a big challenge to internalize knowledge. It is a completely new area of the company. I joined the company because of this. I did not come from the food area; I am from the cellular biology, tissue gene area, which is a specifically important knowledge for cultivated meat. There is a certain difficulty in bringing knowledge and convincing people inside the company that this is something feasible, that it can be part of our portfolio."* This statement exemplifies the required level of tacit knowledge on the part of employees that demands efforts both for understanding and adoption, as shown in the literature (Silva et al., 2023).

The interviewer emphasizes that, some answers given to other questions that did not refer directly to the Complexity dimension showed that, for some interviewees, it is difficult to understand how the system to produce alternative proteins works and how to use it, despite their strategic position and their work with alternative proteins. This fact can be seen in answers like *"it's hard to speak with technical clarity, with wisdom even, how we develop this alternative protein. I don't know"*, from I7. It is necessary to analyze in recent studies if, for operational levels, the difficulty of understanding may be even greater, which would affect the Complexity dimension.

4.4 Testability

The Testability dimension is related to the degree to which the system to produce alternative proteins has been tested by the organization, even on a limited scale. Besides that, the dimension also addresses the suppliers and partnership communication, and their capability to create awareness and influence potential organizations' perceptions about the innovation (Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky, Fleischer & Chakrabarti, 1990; Tornatzky & Klein, 1982).

More than half of the interviewees reported that they did not participate in the testing phase, as presented in Table 13, even though they work in R&D sectors, since the production of alternative proteins is outsourced and executed by partner companies. Some

interviewees were involved in the testing phase, but they emphasized that the partner company was responsible for this. Currently some of the companies have already started to produce the alternative proteins internally, but the initial production and the testing phase was the responsibility of the partners. This information corroborates the importance of addressing adequate attention to this dimension, as mentioned in the literature, as the knowledge and skill set of a given innovation may vary significantly among adopters. In the case of alternative proteins it is possible to verify that the companies don't have the knowledge needed to conduct the tests (Aamir et al., 2023; Iskender et al., 2022).

Table 13 - How was the test phase?

Category	No. of responses	Frequency
Unable to opine because did not participate in the test phase	16	55%
Participated in the test phase, but as a supporting player	8	28%

Source: elaborated by the author

The search for partnerships occurred due to the lack of suppliers and technologies in Brazil to develop the products, as already mentioned in the analysis of the dimension Compatibility and Market Demand. I23 explains, *"At the beginning (of the adoption) we brought imported products. Then we developed technologies, through a research and development team that, together with partners, ingredients houses and flavor houses, are always researching recent technologies."* Interviewee I25 shows in his speech the dependence on the partners in the case of the adoption of cultured meat: *"in the case of cultured meat, we still don't have a structure to produce it. So, we trust in our partner, the Israeli startup, that this is well developed by them. It is a technology that they dominate and that we will bring to Brazil, until we define the route we are going to adopt."*

4.5 Visibility

The dimension Visibility refers to how visible are the results of adopting alternative proteins and for most of the interviewees, the visible result brought by the adoption was the increase in brand visibility. Some interviewees also cited that the adoption of alternative proteins allowed them to reach new markets. These results, although mentioned by the interviewees as visible, have not been translated into numbers and facts by any of them which makes these issues more related to the dimension Relative Advantage than to the

dimension Visibility (Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982).

Table 14 - Visible results brought by the adoption

Category	No. of responses	Frequency
Increased brand visibility	13	45%
Results are not visible so far	10	34%
Reached new markets and consumers	7	24%

Source: elaborated by the author

For many interviewees, the results obtained are not yet visible, as presented in Table 14, and I16 explains why: *"There is still not enough time to develop the category as it should be. What really got in the way was what happened in the last two years (2021 and 2022), with inflation and loss of purchasing power... the cost of the protein industry went up, as a whole. Therefore, the Brazilian consumer has been replacing beef protein for pork protein. Moreover, those who used to eat beef have been eating chicken. This has slowed down the development of the alternative protein industries because the product is very expensive. This is a medium to long-term bet, not a short-term bet. I don't think we are at a moment when the consumer is willing to pay for that."*

4.6 Uncertainty

The dimension Uncertainty is related to the degree of technical, financial and/or social uncertainty in adopting alternative proteins. Interviewees cited seven categories about their perception of uncertainty regarding the adoption, whether from a technical, financial, and social point of view. The most cited category was the fact that the alternative protein is a product that has only been on the market for a brief time or is not yet available, as cultured meat, as presented in Table 15. Due to the brief time on the market, alternative proteins are not yet established and have not brought concrete results for companies, generating uncertainty. For others, the uncertainty is about the adoption or non-adoption by consumers and, consequently, what will be the size of the market for these products. There is also uncertainty regarding the financial return that the investment in this market will bring, if it does, and at what prices the products will reach the market (Frambach & Schillewaert, 2002; Nooteboom, 1989).

Table 15 - Uncertainty of the alternative protein market

Category	No. of responses	Frequency
New product	9	31%
The consumer will adopt?	7	24%
Is it going to bring financial return?	6	21%
Is it healthier and causes less impact on the environment?	5	17%
Is industrial scale production feasible?	5	17%
It is certain that alternative proteins will always exist on the market	5	17%
Which players will survive?	3	10%

Source: elaborated by the author

Two other categories of uncertainty were cited: whether alternative proteins are really healthier and have less impact on the environment than animal meat; and whether production on an industrial scale is feasible. As for production, I26 comments, *"the bases* (for production) *are well established. However, to become a product, it is necessary to migrate from the lab bench to actually go to the industry, and this is not as simple as scientists imagined are. Therefore, startups are still 'rowing' a long way to reach production practice. That is why we still don't have this product being commercialized on a large scale."*

Some interviewee's state that, despite the various uncertainties, there is no doubt that alternative proteins will remain in the market, even if as a small and not very profitable category. For a minority of interviewees, there is uncertainty about which producers, suppliers and others involved in the process of adopting alternative proteins will survive and stand out in the market, given the categories of uncertainty mentioned above.

5 FINAL CONSIDERATIONS

This article aims to identify the perceived innovation characteristics that may influence innovation adoption. To this end, a theoretical discussion of the main perceived innovation characteristics proposed in the literature was conducted and the dimensions that have synergy with the agri-food system were identified, namely: Compatibility and Market Demand; Relative or Economic Advantage; Complexity; Testability; Visibility; Uncertainty. These dimensions were applied and explored with twenty-nine managers and leaders who are involved in the process of adopting alternative proteins in the agri-food system in Brazil.

The dimension Compatibility and Market Demand represented an important development in the context of the agri-food system, since it was possible to verify that the

results obtained with the adoption of alternative proteins by companies operating in the segment have not kept up with expectations and that alternative proteins have encountered many barriers in the adoption process. The current moment of the alternative protein market is one of stagnation and readjustment, and these barriers, such as nutritional, taste and experimentability issues must be faced by organizations, as well as the need for adjustments in the definition of strategy, communication, and positioning.

The Relative or Economic Advantage dimension has shown that the adoption of alternative proteins has not yet brought economic advantages so far. However, the adoption has been beneficial in terms of reinforcing brand values and positioning, bringing benefits in terms of social prestige, keeping companies competitive in the market, and allowing them to reach new customers and markets, points that are also confirmed by the analysis of the Visibility dimension. With regards to the Complexity dimension, it was possible to verify that the alternative proteins are considered complex by those involved, since they have a production process that is quite different from what the company was already doing and from the chain already established. The complexity of understanding a new market and a new brand positioning and the search for new suppliers and partners influence the adoption of alternative proteins. The dimension Uncertainty also brought commonalities, such as the fact that the product has only been on the market for a brief time or, in the case of cultured meat, is not yet available. It is still uncertain for the interviewees whether there will be consumer adoption of the products and, consequently, whether there will be a financial return on the investment made in the adoption. Market research and trends are positive and optimistic, but it is necessary to follow the market and constantly update the trends.

A point of interest is the Testability dimension. The fact that the vast majority of interviewees were not directly involved in the testing and product design phase shows the great dependence on partners for the production of alternative proteins. The search for partnerships was due to the lack of suppliers and technologies in Brazil to develop the products. It is evident that there is a need for investment in R&D in the country regarding alternative proteins, so that companies can have total control of the production and deep knowledge of the product, which would also have a positive impact on the dimensions Complexity and Uncertainty.

The article contributes to the literature on the innovation adoption by adding new perspectives on the perceived innovation characteristics, considering the specificities of the Brazil agri-food system. The article also contributes to reducing the literature gap regarding the alternative proteins adoption, identified in the systematic literature review conducted in

article 1 of this thesis. In addition, the article provides practical contributions by collecting information on the innovation adoption in the agri-food system, what is currently working well and what needs more attention from those involved in the sector. The study has limitations, such as the number of respondents and the fact that it was limited to one production sector. In future studies, it is recommended to increase the number of interviewees and to include employees from other hierarchical levels, such as the production sector, who are directly involved in the innovation adoption.

ARTICLE 3 - Innovation Adoption in the Agri-food System: the influence of external variables and internal characteristics of organizations

SUMMARY

The agri-food system plays an important role in the economies of countries and has unique characteristics. Organizations in this sector face changes in market and consumer demand, as well as environmental challenges. One way to address these changes is through the adoption of innovation, which allows organizations to remain competitive and sustainable over time. Innovation adoption is influenced by dimensions related to external variables and the internal characteristics of the organization, which can vary from one industry to another. Adopting innovation requires an in-depth knowledge of these dimensions. Thus, the main objective of this article is to analyze the influence of external variables and internal characteristics on innovation adoption in the agri-food system. To this end, semi-structured interviews were conducted with managers involved in the innovation adoption in the agri-food system, and content analysis technique were used to analyze the data. It was found that external variables, such as Network Externalities, Competitive Environment and Legislation, do not receive adequate attention from agri-food organizations. Among the internal characteristics, the Innovativeness dimension receives great attention, and the Business Relationships and Key Individuals dimensions have some well-researched aspects, but others that still require attention.

Keywords: innovation adoption; agri-food system; external variables; internal characteristics.

1 INTRODUCTION

Global markets face increasing competition that challenges organizations to maintain the usefulness and relevance of their products and services. In previous studies conducted to identify the factors associated with the success and failure of new products, the main finding is that those that fail were not focused on meeting customer needs and were not superior to alternatives available in the market. Competitive organizations are those that are open to innovation and use their knowledge to seek and identify these opportunities. Thus, the innovation adoption is shown as a powerful tool to face and stand out in this competitive environment, creating differentials that generate advantages and long-term sustainability. Identifying in advance the factors influencing the innovation adoption and the opportunities created by innovations, allows organizations to act quickly in restructuring and adapting themselves, besides enabling the proper exploitation of innovative products, services and processes (Montes de Oca Munguia, Pannell &

Llewellyn, 2021; Ploll et al., 2022; Timpanaro et al., 2023).

Given this reality, it is of great interest to understand the process of innovation adoption in different organizations and the dimensions that can influence the adoption in specific contexts. The innovation adoption in the agri-food system is an increasingly relevant topic, given the economic importance of the sector for the world's economies and the major challenges it faces in meeting the rapidly growing population, the climate crises that directly affect it, and the new market demands for safe and healthy food. An important innovation in the agri-food system is the alternative protein, chosen as the object of this study, a protein that replicates the texture, flavor and appearance of meat, but is made from non-conventional sources of protein such as vegetables, plants and algae (Bower & Christensen, 1995; Frambach & Schillewaert, 2002; Marôcco, Porto, Oliveira & Zanetti., 2014; Montoya-Weiss & Calantone, 1994; Timpanaro et al., 2023).

There are several studies in literature that have analyzed the innovation adoption and identified dimensions that can influence this process. Dimensions external to the organization, such as Network Externalities, Competitive Environment, and Legislation, as well as characteristics internal to the organization, such as Business Relationships, the presence of Key Individuals, and acceptance of change and new things, known as Innovativeness, are some of the dimensions identified in the literature. However, few studies consider the current reality and specificities of the agri-food system and it is necessary to understand which dimensions influence the innovation adoption in this segment (Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Singh et al., 2023; Wairimu et al., 2022)

Considering all these issues, the main objective of this article is to analyze the influence of external variables and internal characteristics on innovation adoption in the agri-food system. The specific objectives are: To explore the influence of Network Externalities, Competitive Environment, and Legislation in the innovation adoption; to explore the influence of Innovativeness, Business Relationship and Key Individuals in the agri-food system; to identify the influence of external variables and internal characteristics in the process of innovation adoption in the agri-food system. To achieve these objectives, semi-structured interviews were conducted with twenty-nine managers involved in the innovation adoption in the agri-food system, and content analysis technique were used to analyze the data, divided into two types: frequency and thematic (Bardin, 2004, 2016; Minayo, 2014).

This article presents theoretical and practical contributions. For the literature, the

article enriches it by presenting more data sources that consider the Brazilian context, as well as verifying which internal and external variables are identified as fundamental for the innovation adoption and which are not. In terms of practical contributions, the article raises considerations for managers making decisions about innovation adoption, pointing out which dimensions are increasingly used, which are not, and which should receive more attention.

This article is structured in four sections, besides this introduction. In the next section, the theoretical framework is addressed in the following topics: (i) influence of external variables; (ii) influence of internal characteristics. Following are the methodological procedures, the results and discussions. Finally are presented the final considerations including limitations and proposals for future studies.

2 THEORETICAL REFERENCE

Innovation adoption is the decision of any individual or organization to use or not use an innovation. This study focus on innovation adoption at the organizational level, which occurs through the adoption of new products, services, processes, programs, systems, equipment and/or politics, whether they are generated within the organization itself, or in its external environment. The innovation adoption enable organizations to create differentials that generate advantages and long-term sustainability and is the key to organizations to face and stand out in competitive environments, (Daft, 1978; Damanpour & Gopalakrishnan, 1998; Davis, 1989; Rogers, 2003; Singh et al., 2023).

Over the years, many models of innovation adoption have been developed and proposed in order to analyze the dimensions that influence adoption. The aim of the models is to provide a structured way of analysis and a method to understand the impacts of different dimensions on the adoption process. Therefore, the models differ and may be more suitable for a particular context or for the specific needs of the study in which they are employed, and all have strengths and limitations (Aamir et al., 2023; Gharibi, 2020; Montes de Oca Munguia, Pannell & Llewellyn, 2021). From the literature, six dimensions that are related to the agri-food system and are related to each other were identified and will be analyzed in this article. The dimensions were divided into two groups, namely external variables, and internal characteristics, and are detailed in the topic below.

2.1 Influence of External Variables

Among the dimensions that influence the innovation adoption, there are those that are related to factors external to the organization, such as: Network Externalities (Cox et al., 2002; Frambach & Schillewaert, 2002; Kastelli, Tsakanikas & Caloghirou, 2016), Competitive Environment (Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti, 1990), and Legislation (Bryant, 2020; Ettlie, 1983b; Morais-da-Silva et al., 2022; Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023). In this topic, each of these variables will be thoroughly addressed to achieve a better understanding of the influence they may exert on the innovation adoption process.

2.1.1 Network Externalities

It is known that during the Industrial Age, several manufacturing industries found themselves in need of adopting innovations in their production processes to meet new demands and complex tasks that emerged in the market. These industries were equally affected by the Information Age, which altered and facilitated the relationships between organizations in the market. In this Age, interfirm networks were formed, playing a significant role in reducing the barriers that organizations faced when accessing the market. These networks created mechanisms such as information and communication technologies (ICTs) systems and relational contracts, which are mutual agreements of broad cooperation and communication between the parties, aiming to smooth the counterpoint relationship between companies and the market (Cox et al., 2002; Singh et al., 2023).

The creation of frozen foods in the 1960s and 1970s was an important moment for the agri-food system and its components. The technology of quick freezing demanded changes in distribution processes, raw material supply, wholesale, and retail sales routines, and, of course, a shift in family consumption patterns. During that time, the large company Unilever successfully coordinated the innovation adoption and generated business partners opportunities among new stakeholders at distinct stages of the supply chain. Additionally, the relationship between retailers and large industries resulted in significant business partners, with retailers adding their own-label products to the mix of goods produced by large food processors (Cox et al., 2002).

An important process of continuous product innovation began as mutual agreements of broad cooperation and communication between the parties strengthened, promoting the

integration and exchange of knowledge among stakeholders in the food supply chain, such as manufacturers, packaging companies, and multidisciplinary teams. In this context, ICT played a fundamental role in facilitating the aggregation of diverse knowledge sources, reinforcing collaborative ties between business partners. Additionally, ICT allowed for a shift in consumer communication, transitioning from unilateral communication, where only companies communicated with customers, to bilateral communication, enabling information exchange between customers and companies and the possibility of trend anticipation (Cox et al., 2002; Kastelli et al., 2016).

Mutual agreements and the formation of strategic alliances have also become influential factors in the decision to adopt innovations. It is believed that the innovation adoption can be influenced by the number of interrelated organizations that have already adopted the innovation and by the level of knowledge about the innovation that the stakeholders involved in the industry have. The usefulness and value of an innovation increase according to the increase in the number of competitors, suppliers, partners, customers, and other adopting actors. This type of influence has been termed in the literature as Network Externalities or critical mass (Frambach & Schillewaert, 2002; Rogers, 2003; Singh et al., 2023).

The development of innovations in the agri-food system involves multidisciplinary action, mutual agreements of broad cooperation and communication between the parties to co-create solutions and innovations with external stakeholders and sources. These actions allow innovation to occur in high-tech industries, but also in small retailers and low-tech industries. Thus, the components of the agri-food system play a fundamental role in the development of innovations that not only strengthen the sector itself but also various other sectors that are economically relevant (Cox et al., 2002; Kastelli et al., 2016; Marzi et al., 2023).

2.1.2 Competitive Environment

Based on the adoption principles initially spread by Everett Rogers, a study presents two sets of factors that impact innovation adoption in highly competitive environments: the first related to the supply-side competitive environment, including structural and resource commitment factors, and the second referring to the adopter industry competitive environment, involving structural and communication components. Twelve factors are thoroughly analyzed concerning innovation adoption, providing propositions that relate the

components to the timing and/or depth of adoption. In conclusion, it is determined that factors such as explanations related to innovation reliability, new products and pricing along with other factors positively influence the speed and level of innovation adoption in business contexts (Robertson & Gatignon, 1986; Rogers, 2003).

In the reality of competitive environments, the adoption of innovations can be a strategy to gain a competitive advantage and stand out against the competition. More than just a strategic decision, being immersed in a highly competitive environment is a stimulating factor for the innovation adoption. Being among the early adopters, i.e., the first organizations to adopt a certain innovation, brings advantages to the organizations since they become opinion leaders, set a cost standard and service standard. These organizations can conquer a share of the market that was expecting the innovation and had not had their request met until now. In the case of organizations that have not had the benefit of being early adopters, the existence of technologies and innovations in the market can influence the adoption, since they may serve as a path to be followed, indicating how companies can improve when adopting innovation. Starting from this principle, the degree to which the innovation adoption is necessary to maintain the competitive position relative to competitors is a dimension of innovation adoption process named as Competitive Environment (Amini & Javid, 2023; Silva et al., 2023; Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti., 1990).

2.1.3 Legislation

Industry regulation has been long-standing and exerts an important influence, especially in the agri-food system. Some companies are required to adapt their operations to comply with policies and regulations, whether due to environmental, nutritional or consumer convenience causes. However, studies shows that policy is a strong barrier in innovation adoption and previous study on national innovation policies and their implications for innovation processes in the US food sector found that government influence tends to discourage the innovation adoption in the sector. This is due to factors such as lengthy decision-making processes, as in patent processes for example, poor consistency in regulation and lack of clarification on these, and lack of protocols for labels and coding objects (Ettlie, 1983b; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023; Wasiq, Kamal & Ali, 2023).

The adoption of any innovation, due to its inaugural character, may face challenges

related to policy formulation. In the case of the agri-food system it can be even more complex, as for alternative proteins that are a food product and issues such as food quality and safety are critical. In addition, the food supply chain is complex, mainly because it involves different countries and regions that have different restrictions and regulations, so it requires a deep full and careful study, so that robust regulatory policies can be developed. In the case of cultured meat, a specific type of alternative protein, the European Union was the initiating driver on regulatory issues in 2018, later receiving active support from the United States, followed by Israel and Singapore. In 2020, Singapore was the first country to approve the sale of cultured meat followed by the US, which made the approval in June 2023 (Bryant, 2020; Guan et al., 2021; Qiu, 2023; Vu, Ghadge & Bourlakis, 2023).

Since then, studies on the topic have been growing and the regulatory framework is evolving in other countries. However, the absence of food policies can slow down the innovation adoption and, in this case, the advancement of alternative proteins. There are still many questions to be addressed, such as what will be the correct nomenclature to be used, guarantees that the product is safe for consumption and packaging rules that do not lead to any confusion for the consumer. Given this scenario, it is necessary to analyze if normative pressures are influencing innovation adoption. To this end, the Legislation dimension was included in the present study (Bryant, 2020; Morais-da-Silva et al., 2022).

2.2 Influence of Internal Characteristics

Among the dimensions that influence the innovation adoption, there are those that are related to internal characteristics of the organization, such as: Innovativeness (Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Makkonen et al., 2016; Rogers, 2003), Business Relationship (Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam, Dunn & McCall., 2014; Rogers, 2003; Wairimu et al., 2022), and Key Individuals (Annamalah, Aravindan, Raman & Paraman, 2022; Damanpour & Schneider, 2009; Ettlie, 1983b; Makkonen et al., 2016; Wairimu et al., 2022).

2.2.1 Innovativeness

Innovativeness is related to the openness, acceptance, and tolerance of changes and

new things. Organizational members are more likely to exhibit positive attitudes toward an innovation, given the influence of the organization's strategic decisions. This influence constitutes a dimension related to the innovation adoption, named in the literature as Innovativeness. These observed usage levels may become so compelling that the opportunity cost for an individual to resist the innovation becomes too high, potentially overcoming any initial negative attitudes (Davis, Bagozzi & Warshaw, 1989; Frambach & Schillewaert, 2002; Stroh, Mention & Duff, 2023).

The propensity to adopt innovations is not solely dependent on attitudes but is also influenced by management strategies, policies, and actions. Internal marketing variables, including training, education, organizational technical support, incentives, and control structures, play a significant role in determining the relevance of an innovation and its adoption. Additionally, the innovation adoption by an individual's peers, such as superiors, colleagues, and customers, can signal its importance and advantages and, more than that, affect the social relationship of belonging to a group, thus motivating the adoption among all other members of the organization (Davis, Bagozzi & Warshaw, 1989; Frambach & Schillewaert, 2002; Stroh, Mention & Duff, 2023).

There are several studies that examine the effects of strategic decisions and organizational characteristics and structure on the innovation adoption process. An organization’s strategic decisions and structural characteristics have a stronger influence on innovation adoption, and the influence can vary according to the different phases of the adoption process. For example, considering organizational complexity, it was observed that it has a positive influence on the initiation phase but not on the implementation phase. Another relevant finding is the positive effect of organizational economic health and the negative effect of trade unions on the adoption decision. The results suggest that both the availability of organizational resources and the presence of trade unions may have a more major influence on top managers' decision to adopt innovation compared to their influence on the initiation or implementation phases. As innovation adoption requires interaction and a good information flow, the organizational structure is a critical influence in all phases of the innovation process (Silva et al., 2023; Damanpour & Schneider, 2006; Singh et al., 2023).

The decision-making process and the strategic decisions and directions of the organization are important influencing factors in the innovation adoption. Administrative innovations predominantly follow a top-down adoption process, with initiation occurring in the administrative core and implementation in the technical core. On the other hand,

technological innovations tend to follow a bottom-up process, with initiation happening in the technical core and implementation in the administrative core (Daft, 1978; Rogers, 2003; Singh et al., 2023; Wasiq, Kamal & Ali, 2023).

2.2.2 Business Relationship

Particularly in the agri-food system, innovation networks are becoming increasingly significant. In the European Union in recent years, national and regional policy makers have focused on implementing policies to encourage the innovation adoption in their agri-food companies in order to accelerate the economy of the countries. For this to happen, one of the actions taken is to stimulate inter-organizational cooperation and networking since many companies, especially small and medium-sized ones, do not have sufficient resources and capabilities to innovate with their internal resources alone (Batterink et al., 2010; O'Connor & Kelly, 2017; Wasiq, Kamal & Ali, 2023).

Cooperative relationships between companies and other parties seeking innovation are called innovation networks. A study with small and medium-sized enterprises in the agri-food system in Germany, France and Netherlands conclude that innovation networks with divergent organization may provide great added value in innovation adoption. This can occur especially when the firm takes on a role of orchestrating networks, assuming the leadership and roles of being the innovation initiator and managing the innovation process. In addition, the innovation initiator, or the leading company, has the power to encourage and pressure other organizations in the chain to adopt a particular innovation, so that the results of the adoption are greater. In the food supply chain, for example, Walmart requires its farmers and suppliers to join its block chain system, since the benefits of block chain adoption are multiplied if everyone involved in the process also adopts the innovation (Batterink et al., 2010; Vu, Ghadge & Bourlakis, 2023).

Low and medium-tech industries and small and medium-sized enterprises have limited resources and opportunities and are less equipped to deal with the risks inherent in R&D investment. Thus, activities such as inter-firm interaction, shared experiences and technology transfer are quite relevant as a mechanism to enhance innovation and can provide significant benefits to those involved. Technology transfer allows firms in a particular sector to take advantage of technological advances in other business fields and create opportunities for higher returns to their operations (Kastelli et al., 2016; Trott & Simms, 2017; Wasiq, Kamal & Ali, 2023).

In this perspective, another important possibility is open innovation, which assumes that innovation is a collaborative process that depends on the interaction between the internal and external orientation of a company. The open innovation model argues that network collaboration is an important external component within the innovation process, thus being a way to reduce the limitations of companies, whether in terms of financial, technological, knowledge, workforce, and other resources. Food technology industries increasingly rely on external knowledge in their R&D processes and do so through outsourcing, strategic alliances and open innovation activities (Chesbrough, 2003; Flipse & Van der Sanden, et al., 2013).

Thus, an important dimension in the analysis of innovation adoption is the Business Relationship that is related to the degree to which organizations share information and knowledge internally and externally, are open to joint product development, create interaction networks and connections within the their sectors and with other sectors, including technology providers, companies and competitors (Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam et al., 2014; Rogers, 2003; Wairimu et al., 2022).

2.2.3 Key Individuals

Key Individuals is the dimension that analyzes the presence of skilled labor and human resources exclusively dedicated to innovation processes in the organization. A study conducted with managers in large food processing companies found that these key individuals play a crucial role in fostering employees' innovative behavior and facilitating the innovation adoption. Interdisciplinary coordination and substantial operational management changes are required and there must be collaboration and coordination of different departments and divisions. Skilled key resources contribute to this occurring successfully and play a key role in the dissemination of innovation due to their organizational learning capacity and mediation skills. It was concluded that key individuals are those who: constantly question the current performance and routines of the company; support the process of identifying potential needs; pay attention to matching solutions with the identified needs; and possess the ability to make decisions regarding the best fit between needs and solutions (Amini & Javid, 2023; Silva et al., 2023; Makkonen et al., 2016).

Besides that, in an organizational context, cultivating a pro-innovation attitude is

vital to drive successful innovation adoption. Organizations aim to shape their subordinates' attitudes towards embracing innovations, recognizing that individuals may exhibit varying degrees of readiness for accepting certain innovations. A crucial determinant of innovation adoption is the degree to which members of the organization are receptive to change. Studies hypothesize that organizational members are more likely to embrace innovation when their work environment fosters a culture oriented towards innovation. This innovation-oriented culture can exert direct effects, prompting individuals to align with the prevailing norms, or indirect effects by influencing individuals' attitudes through internalization or identification processes (Frambach & Schillewaert, 2002; Zaltman, Holbek & Duncan, 1973).

An important concept related to organizational cultures and innovation adoption is the concept of integrative culture that emphasizes the adoption of external practices, with attention and care to maintain and preserve existing cultural values. This type of culture is essential in the process of innovation adoption, as it promotes relevant standards, high performance, refined innovation, and adaptability. Integrative culture encourages active participation and fosters a collaborative environment within the organization and studies have shown a positive correlation between a highly integrative culture and successful innovation adoption. A culture focused on encouragement and commitment also shows a positive influence on employee innovation adoption. By fostering employee commitment and performance-oriented behaviors, the culture oriented towards the “pro-innovation attitude” motivates and supports the organization's endeavors. Nurturing an organizational culture that supports and encourages innovation can significantly enhance the likelihood of successful innovation adoption and implementation and is directly related to the presence of key individuals in the adoption process (Annamalah et al., 2022; Wasiq, Kamal & Ali, 2023).

3 METHODOLOGY

Data collection was conducted through interviews, as a technique that allows the interviewer to have access to the interviewee's experiences, opinions, thoughts, perspectives, and feelings, enabling access to deeper information than observation can provide. Semi-structured interviews were applied, as a qualitative data collection, starting with a pre-defined set of questions and as the interview progresses the interviewer can add or remove questions. An interview script is used as a guide to ensure that the main topics

are covered, so that the answers can be used and compared during the stage of data analysis (Boni & Quaresma, 2005; Eisenhardt, 2021; Eisenhardt & Graebner, 2007; Langley & Abdallah, 2011; Lune & Berg, 2017; Patton, 2002).

The interviews were conducted with twenty-nine managers and leaders who are involved in the process of adopting alternative proteins in the agri-food system in Brazil, using the Snowball Sampling in which the interviewee is asked to recommend potential participants who meet the study criteria to participate in the interview. This is an easy-to-implement technique and a suitable approach when it is difficult to access participants. The interviewees have an average of 5 years working in the organization, with strategic positions such as directors, managers, coordinators, supervisors, and specialists. The identification of each respondent, their position and the length of time working in the organization is described in Appendix F (Handcock & Gile, 2011).

The data collection process was composed of three stages: planning, execution, and post-execution. At the planning stage, the following steps were followed:

1) Definition of the project scope and research objective: based on the literature survey, six dimensions that are related to the agri-food system and are related to each other were identified to be analyzed. The dimensions were divided into two groups, namely External Variables and Internal Characteristics, as presented at Table 16.

Table 16 - Dimensions proposed

Dimensions	Description	Reference
2. Influence of External Variables		
2.1 Network Externalities	Degree to which business partners (organizations and/or suppliers in the agri-food system) have already adopted alternative proteins, thus increasing the innovation usefulness.	(Cox et al., 2002; Frambach & Schillewaert, 2002; Kastelli et al., 2016)
2.2 Competitive Environment	Degree to which the adoption of alternative proteins is necessary to maintain the competitive position relative to competitors in the agri-food system.	(Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti, 1990)
2.3 Legislation	Influence of normative pressures and policies on alternative proteins adoption by organizations in the agri-food system.	(Bryant, 2020; Ettlie, 1983b; Morais-da-Silva et al., 2022; Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023)
3. Influence of Internal Characteristics		
3.1 Innovativeness	Degree of propensity to adopt innovations, given the influence of the organization's strategic decisions.	(Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Makkonen et al., 2016; Rogers, 2003)

3.2 Business Relationship	Degree to which organizations share information and knowledge internally and externally, are open to joint product development, create interaction networks and connections within the agri-food system and with other sectors, including technology providers, companies, and competitors.	(Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam et al., 2014; Rogers, 2003; Wairimu et al., 2022)
3.3 Key Individuals	Presence of skilled labor and human resources exclusively dedicated to innovation processes and organizational culture oriented towards the "pro-innovation attitude."	(Annamalah et al., 2022; Damanpour & Schneider, 2009; Ettlie, 1983b; Makkonen et al., 2016; Wairimu et al., 2022)

Source: elaborated by the author

2) Construction of the interview script: a preliminary outline of the script was prepared based on the literature survey of the six dimensions defined. A table has been created linking each dimension with the questions that allow the dimension to be investigated during the interview, as presented in Appendix E. A pre-test of the script was carried out, with two PhD researchers, in January 2023. In addition, three expert evaluators, with extensive experience in research, academic and market experience in the field of innovation, assisted in the interview script review, resulting in the replacement of questions that might be obvious to adopting companies and adaptation in questions related to the testing phase and the complexity of product development. The final interview script after the revision is presented in Appendix D.
3) Identification of the interviewees: Participants in the sample were selected through purpose, where each respondent is selected to maximize the marginal value of the information obtained, and the Snowball Sampling technique as also used (Handcock & Gile, 2011; Langley & Abdallah, 2011; Patton, 2002).

In the execution stage, the twenty-nine interviews were conducted by video calls between January and March of 2023, and had an average duration of 40 minutes. At the beginning of all interviews, the following information was given to the interviewee: the objectives of the study; what will be done with the search results; how respondents were selected; confidentiality of the responses of each interviewee; request for permission to recording; presentation and signature of the Consent Form, presented in Appendix G; clarification of possible doubts.

In the post-execution stage, the interviews transcription was done using the free web application "oTranscribe" and the transcripts were sent to the interviewees so that they

could confirm the information. When necessary, adjustments can be made to the transcripts according to the interviewees' appointment, but that was not necessary (Langley & Abdallah, 2011; Lincoln & Guba, 1985).

Data analysis was carried out using the content analysis technique, which uses systematic and objective procedures to analyze the interviewees' statements. Frequency analysis was used from a mixed grid, in which categories were defined in advance from the literature (closed grid), but categories that emerged from the field were also allowed. The method of thematic analysis was also used, in order to identify a core of meaning on certain topics in the interviewees' answers (Bardin, 2004, 2016; Minayo, 2014).

4 RESULTS AND DISCUSSION

Through interviews with managers and leaders who are involved in the process of adopting alternative proteins in the agri-food system it was possible to obtain data that allowed for an in-depth analysis of the dimensions that influence innovation adoption, which is presented below. Interviewees will be identified as I (interviewee) plus the interview number.

4.1 Network Externalities

The dimension Network Externalities, which compose the influence of external variables, are related to the degree to which business partners have already adopted alternative proteins, thus increasing the innovation usefulness. One can consider business partners as the partners, stakeholders and/or suppliers in the agri-food system (Cox et al., 2002; Frambach & Schillewaert, 2002; Kastelli et al., 2016).

Table 17 - Adoption by partners, stakeholders, and suppliers

Category	No. of responses	Frequency
Could not answer	12	41%
Suppliers have adopted	12	41%
Major supermarket chains have adopted	6	21%

Source: elaborated by the author

Almost half of the interviewees had difficulty answering questions about innovation adoption of alternative proteins by their primary business partners. They informed that they do not have this kind of information about their partners, as presented in Table 17. On the

other side, the same number of interviewees mentioned that some suppliers of flavoring and additives have adopted the alternative proteins and that, although they are still in the early stages of adoption, they are able to provide products that assist in the manufacture of alternative proteins. The literature states that it is necessary a multidisciplinary action in the development of innovations in the agri-food system and that communication and cooperation between the parties can lead to innovations in high-tech and low-tech industries. The large percentage of respondents claiming to have no information on the adoption of alternative proteins by their partners may indicate that a greater connection needs to be established in order to obtain the benefits that it can generate (Kastelli et al., 2016; Marzi et al., 2023).

I8 affirmed, *"Now we have seen some suppliers working with protein-rich vegetables and entering this segment. We see a very big evolution of several suppliers with stabilization systems and flavor modulators,"* which are necessary ingredients for the production of alternative proteins. The interviewee also informed that *"traditionally, only soy was considered with this functionality by the suppliers,"* but that this is already outdated in the market. This statement acknowledges studies that confirm the importance of industry stakeholders having knowledge of the innovations to be adopted in order for the adoption process to be efficient (Singh et al., 2023).

The large supermarket chains, important partners of the agri-food system companies, have also adopted alternative proteins, according to a small proportion of the interviewees. I13 comments that *"the big chains have adopted alternative proteins for all types of consumers, embracing vegans, vegetarians, omnivores, everything. But the small retailers, I don't see so much demand for them yet."*

4.2 Competitive Environment

Another dimension that composes the influence of external variables is the Competitive Environment which can be explained as the degree to which the adoption of alternative proteins is necessary to maintain the competitive position relative to competitors in the agri-food system (Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti, 1990).

Table 18 - Adoption by direct and indirect competitors

Category	No. of responses	Frequency
Yes. Named one competitor.	18	62%
Yes. Named two competitors.	9	31%
Yes. Named three competitors.	2	7%

Source: elaborated by the author

Regarding the adoption by their direct and indirect competitors, the majority of interviewees cited only one competitor as an adopter of alternative proteins, and some interviewees cited two or three competitors, as presented in Table 18. These interviewees made statements that may demonstrate a certain level of negligence in monitoring the competition, such as: *"What I will answer to you is what I see in advertisements in the media"* (I17) and *"I know that company x, our major competitor, had a project so that in 2024 the in vitro meat would already be launched in the market, but I haven't read anything more recent about it"* (I6).

Table 19 - How the adoption by competitors can affect the company

Category	No. of responses	Frequency
Market positioning	10	34%
Losing/acquiring market share	8	28%
Advantage of pioneering	7	24%
Does not affect	4	14%
Market strengthening	4	14%
Comparison and benchmarking	2	7%

Source: elaborated by the author

In relation to their perception of how the adoption or the non-adoption by the competitors can affect their company, six categories were mentioned by the interviewees, as presented in Table 19. For the majority of interviewees, the adoption by competitors affects the company's market positioning in the presence of a market trend. I24 affirms that *"It's more about positioning strategy, the importance of showing yourself as the company that understands and follows this market movement"*. I16 reinforces this belief with the following statement: *"If I don't create this product now, I will become an outdated brand. We have to be able to meet and understand this young public. Alternative protein is a trend"*. These statements confirm that the existence of technologies and innovations in the market can influence the adoption of innovation, and that they serve as a path to be followed, indicating how companies can evolve if adopting the innovation (Amini & Javid, 2023; Tornatzky, Fleischer & Chakrabarti, 1990).

Some interviewees talked about the market pressure on large companies, almost as an obligation to adopt, as it is possible to identify in the statement of I14: *"the adoption by competitors will force other companies to join this type of technology"*; and I19: *"If all competitors adopt it, we would have to adopt it too. There is no way out."* The second main effect caused by the adoption or non-adoption of competitors cited by interviewees, is

gaining or losing market share, as pointed out by I4: *"if there is a market opportunity and a company like ours doesn't take advantage of this opportunity, some competitor will take advantage of it and will gain these people who are willing to eat alternative proteins".* Interviewees also cited being early adopters as a major advantage for the organization, as early adopters will be the first to serve customers, will drive the most trends and will have the most experience with the market. All these statements are evidence that the innovation adoption can be a strategy to gain a competitive advantage and stand out against the competition and, more than that, it demonstrates the stimulating effects of being immersed in a highly competitive environment (Amini & Javid, 2023; Silva et al., 2023; Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti., 1990).

For a small proportion of interviewees, adoption or non-adoption by competitors does not affect their company. According to these interviewees, it is a still expanding market that has room for everyone and, moreover, as alternative protein is not the company's main product, even if another competitor dominates the market, this will not affect the organization in a relevant way. Other categories were also mentioned less frequently, as: market strengthening, generated by the growth of players in the market; and the possibility of comparison and benchmarking for those companies that want to grow in this market and can have competitors as a parameter.

4.3 Legislation

The final dimension that composes the influence of external variables is Legislation, which is related to the degree in which normative pressures and policies can influence on alternative proteins adoption by organizations in the agri-food system (Bryant, 2020; Ettlie, 1983b; Morais-da-Silva et al., 2022; Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023).

The majority of interviewees reported that they do not have in-depth knowledge about regulatory issues, as presented in Table 20, but that they know this is a complex and significant issue that negatively impacts the adoption of alternative proteins. I18 reported *"I know it influences a lot, but I don't know the details of how because it is not my area of expertise",* as did I1: *"I have no idea how it is currently because these issues sometimes change from one day to the next, but I know it is very bureaucratic"*.

Table 20 - Regulatory pressure

Category	No. of responses	Frequency
Has limited information about it, but knows that the impact is negative	9	31%
Lack of regulation	7	24%
Complicated rules for product naming	6	21%
No regulatory pressure	4	14%
Confidentiality issues	3	10%

Source: elaborated by the author

For some interviewees, the fact that there are no regulations defined so far is what impacts most. I25 states that *"In the case of cultured meat, we don't have regulatory guidelines, so we can't market it yet. It is a critical issue and we still do not have clarity on what will happen. The prospect is that decisions will start to move more quickly. In Brazil we have two major players operating in this market and they want to know how they will reach the market, with which product and even more, whether they will be able to reach it or not "*. I27 corroborates this information, pointing out that *"we are waiting for guidelines to know how we can act or not and hoping that this will happen quickly"*. These statements strengthen the affirmation that the lack of protocols and clarity in legislation is a factor that negatively influences the adoption of innovations (Ettlie, 1983a; Singh et al., 2023).

Another regulatory issue cited by interviewees relates to lack of protocols for naming and coding products, as cited in previous studies (Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023). There is no clarity about the naming rules and this hinders the positioning of products in the market, as reported by I10: *"The regulatory issue was not a problem for plant-based products until then, but it became a problem because it cannot be called hamburger, milk... so this ends up inhibiting some companies to expand the market"*. It is possible to notice that there is a divergence between the opinions of the interviewees regarding the possibilities of naming the products, as in the report of I8 who disagrees with I10: *"I see other players abusing the nomenclature. They name a product that has no meat, only vegetable protein, a hamburger. In my opinion, this product couldn't be named as a hamburger, because hamburgers are made of meat."*

It was possible to verify the influence of this dimension by excerpts such as *"the regulatory issue may be one of the main obstacles"* (I13) and *"this is the biggest impasse"* (I23). Despite this, a small proportion of the interviewees stated that regulatory issues did not influence the adoption or non-adoption of alternative proteins. Respondents who made this statement placed other factors as having a greater influence on adoption, such as structure, investments, and market demand, even though during this question they were not

asked to rank the influencing factors.

Another category also cited less frequently was the influence of regulation on confidential matters. I23 stated that *"it is difficult to give visibility to the regulatory body and guarantee the confidentiality of your development, because that's it, it's a war of who is going to get it before developing the technology forward, so anything you disclose, it can put you at a disadvantage and give visibility of something to your competitor"*. This demonstrates that the need to disclose information, even to a regulatory body, can be an influencing factor in the adoption of alternative proteins.

4.4 Innovativeness

The dimension Innovativeness, that composes the influence of internal characteristics, is the degree of propensity to adopt innovations, given the influence of the organization's strategic decisions and management attitude (Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Makkonen et al., 2016; Rogers, 2003).

Table 21 - Strategic posture have positive influence in the adoption?

Category	No. of responses	Frequency
Yes	18	62%
No	11	38%

Source: elaborated by the author

The vast majority of interviewees believe that their companies' strategic posture positively influences the adoption of alternative proteins, as presented in Table 21. I24 states that *"yes, it is a total vision of innovation and strategy. We know that we have to be connected in those tracks that come with the future, of development, testing, learning, bringing these references to the market, but without losing the clarity that we are a mass company, a company with a democratic portfolio, which wants to serve everyone"*. I25 adds that *"our company has this commitment to be zero carbon by 2040... And alternative proteins also end up being a way of reinforcing this. So, I think there is a broader market strategy, focused on these sustainability issues, not only seeing alternative proteins as a portfolio diversification"*. This comments corroborates the statement that the innovation adoption is related to strategic decisions and management attitude (Silva et al., 2023; Singh et al., 2023; Wasiq, Kamal & Ali, 2023).

For I20 there is a position in favor of alternative proteins, but not globally, as can

be seen in his report: *"it is not a global strategy for the company, but a local strategy in Brazil, which is where we have a market where there is a little more processed and less quantity of basic products, as it is in the rest of our markets around the world"*. I28 also states that *"yes, it had a positive influence, but it was based on an innovative brand position and not so much believing that it would be something to bring a financial value or something that would grow hugely in a short period of time"*.

The other interviewees have a different view and believe that the strategic posture of their organizations does not positively influence the adoption of alternative proteins. For some of them, the decision to adopt is related to market pressure and not to a strategic decision, as reported by I22: *"I don't think it was part of the strategic decisions, it was more a need to be present in the market. When we had some interactions with the consumer, we saw that the product acceptance scores were extremely low. But even so, we had to adopt"*. For I5, the decision to adopt was not something that was on the company's hold map. The interviewee states that *"the company had a more reactive posture. But we kept monitoring the market and if there was a player entering, taking a slice, we saw that we would have to enter soon. But it was not something that was on a hold map"*. The interviewees' reports show that the strategic posture influences the innovation adoption, as previously stated in the literature, either in a positive or negative way (Silva et al., 2023; Singh et al., 2023).

4.5 Business Relationship

The dimension Business Relationship, that also composes the influence of internal characteristics, is the degree to which organizations share information and knowledge internally and externally, are open to joint product development, create interaction networks and connections within the agri-food system and with other sectors, including technology providers, companies and competitors (Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam et al., 2014; Rogers, 2003; Wairimu et al., 2022).

More than half of the interviewees stated that the company shares information and knowledge internally, there is collaboration between sectors and also between branches and subsidiaries in Brazil and elsewhere in the world, as presented in Table 22. It is interesting to mention that, among the interviewees who said this, six of them cited the R&D department as being responsible for this activity and there were three citations for the use

of knowledge management tools, but they did not go into detail about what this tool would be.

Table 22 - Information and knowledge sharing and joint product development

Category	No. of responses	Frequency
Collaboration and knowledge exchange internally	16	55%
Is open to joint development	12	41%
Is not open to joint developments	5	17%

Source: elaborated by the author

A considerable proportion of the interviewees also affirm that their company partners with other companies, suppliers, and researchers to develop products and solutions. I1 comments on the involvement with partners: *"The company collaborates externally with important partners such as local beef and chicken producers and small producers, in addition to providing a laboratory for research in the rural areas, etc"*. I24 comments on partnerships with startups: *"we have an open innovation program, which connects us with startups. Whenever we have a business challenge or technological challenges, we launch this program because there may be a startup that is already working on these challenges."*

In addition, the interviewees commented on the partnerships with other companies for the development of alternative proteins, since they did not have the necessary know-how to develop the product in isolation, as reported by I8: *"We are clear about where our strengths are and where we have a knowledge deficit, and then we reduce these weaknesses with partnerships, such as the partnership with company X"*. I21 corroborates this statement by saying that *"for farmed meat, for example, it would not be possible to enable the company with the necessary laboratories and human resources to develop the product. So, we did some more active searches for partnerships"*. These testimonies strengthen the literature which states that inter-firm interaction, shared experiences and technology transfer allows firms to benefit from technological advances in other business fields and are quite relevant as a mechanism to enhance innovation (Trott & Simms, 2017; Wasiq, Kamal & Ali, 2023).

As presented in Table 23, the vast majority of interviewees said that their organization participate in networks of interaction and connections within the agri-food system and with other sectors, including technology providers, companies and competitors, and participation in fairs, exhibitions, congresses, and conferences were the most cited examples. I5 stated that this type of participation is fundamental and added that *"we make connections with other sectors such as mining, with public research companies such as*

Embrapa, with the Federation of Industries, which is a representative entity and helps us with the connection with startups". I29 cited other interactions in his report: *"There is a very large interaction with Brazilian associations, such as ABPA, other associations of chicken and grain producers as well. And there are organizations in each of the regions that are well connected. It is a market that, because it is considered a commodity, has a highly organized structure that shares information according to compliance."*

Table 23 - Participation in networks of interaction and connections

Category	No. of responses	Frequency
Yes	22	76%
No	5	17%
Not sure	2	7%

Source: elaborated by the author

Following the studies on Business Relationship, a possibility that was not cited by any interviewee, but could be carried out by the organizations that adopted the alternative proteins, would be to suggest and pressure the other parties involved in the chain to also adopt. This action could multiply the benefits of adopting innovation and facilitate the process for the companies involved. The more suppliers adopt the innovation, the more input options the organizations would have to use in the production process, new processes could be adopted and consequently the development of new products would be maximized, among other possible benefits (Vu, Ghadge & Bourlakis, 2023).

Despite this, some interviewees stated that the company does not participate in networks of interaction and connections within the agri-food system and with other sectors, including technology providers, companies, and competitors. I19 stated that *"we do not participate, this is not the focus of the company"*, while I14 said that *"we are part of a market that is very closed and backward in relation to these participations and interactions"*. In addition, 7% of respondents are not sure about the company's participation in networks and other interactions.

4.6 Key Individuals

The dimension Key Individuals, the third that composes the influence of internal characteristics, is related to the presence of skilled labor and human resources exclusively dedicated to innovation processes and organizational culture oriented towards the "pro-innovation attitude" (Annamalah et al., 2022; Damanpour & Schneider, 2009; Ettlie, 1983b; Makkonen et al., 2016; Wairimu et al., 2022).

Table 24 - Presence of key individuals

Category	No. of responses	Frequency
Yes	25	86%
No	4	14%

Source: elaborated by the author

The vast majority of the interviewees affirmed that they could identify the presence of human resources exclusively dedicated to innovation processes in their company, as presented in Table 24. In answering this question, the R&D sector was highly cited as a sector engaged in innovation processes. The same occurred in the analysis of the business relationship and interconnectedness dimension when they were asked if they believe that their organization shares information and knowledge internally, and six interviewees cited the R&D department as being responsible for this activity.

I16 briefly explained the functioning of the R&D department: *"we have an area here only for innovation, R&D, and it is divided by category: chicken innovation, pork innovation, processed innovation... because each one has a market trend"*. In addition, some interviewees detailed that there are innovation teams inserted in other teams, as reported by I21: *"in the marketing sector I have a specific innovation team, in our strategy team I also have a specific team of employees who have this look at innovation ecosystems"*. The four interviewees who answered negatively to this question reported that there are employees who are specialists in innovation, but are not dedicated exclusively to this. These answers show that respondents can identify the presence of skilled labor in the organization, which according to the literature, is a factor that influences the adoption of innovation (Amini & Javid, 2023).

Table 25 - Perception of "pro-innovation attitude" culture

Category	No. of responses	Frequency
A little, not much	14	48%
Yes	10	34%
No	5	17%

Source: elaborated by the author

About their perception of a culture oriented towards a "pro-innovation attitude" that can influence innovation adoption, the prevailing opinion was that the company is innovative, but not much, as presented in Table 25. Some commented that, within the possibilities of the market, the company can be considered innovative, but *"not to a level that would be ideal because it is a very traditional market, with low profit margins and this changes the game a lot. Low margins and perishable products. The immediacy is very great,*

so we have a hard time making medium- and long-term plans. We are more pulled by the market, than we push the market" (I5).

I4 also cited market characteristics as a limiting factor for innovation: *"there is not much product innovation, because there is no way to innovate more in meat cuts. We apply a lot of PDCA projects, continuous improvement projects in processes, improving deboning processes, using knife techniques, packaging processes, to pack faster, safely, processes even for the animal leaving the farm, a process for the ox not to suffer injury inside the truck... but that's what we can do"*. I7 corroborates when he says that *"it has a bit of innovation-oriented culture. A little bit. That is our challenge. Innovating in our sector is complicated"*.

I9 and I24 share the same thought that there is some innovation culture, but in a more traditional model. I9 says that *"there is a culture but in a more traditional company model. We have innovation centers, interaction, innovation culture programs, ideas programs, but you can't compare it with mega innovative companies"*. I24 complements this view, stating that *"there is a bit of this culture, but when you compare it with new economy companies, startups, it is a different model"*. These reports point that this dimension could be better exploited by companies as the literature states that a culture oriented towards a "pro-innovation attitude", focused on commitment and encouragement, can significantly enhance the successful of innovation adoption (Annamalah et al., 2022; Wasiq, Kamal & Ali, 2023).

External factors were raised by I8, I16 and I21 in their reports that companies once had a more innovative culture, but they had to review this position. I16 states that *"I think it was even stronger, until last year. If you take the 2030 plan of company X, one of the main pillars was innovation. But given the whole protein market itself, the costs of grains, the War in Ukraine, all this ended up having a lot of impact. The industries had to focus much more on operations, so there was a stop in encouraging innovation"*. I21 reinforces this view by informing that *"we had to revise a little, given the reality of the market crisis. So we are going back a little, reflecting on our portfolio of innovations, selecting those that we will place more emphasis on, not that we won't do the others, but we can do it at a slightly slower pace, so we're choosing well the fights that we're going to take to the market"*.

I8 also states that it was necessary to review the portfolio of products considered innovative, due to the market's response: *"we were a little impacted in the last two, three years due to the market condition. We saw that many products that we put on the market in*

this more innovative line ended up not giving the purchase performance as expected. Every product launch, even more so when it is a slightly more disruptive innovation, is an exceptionally large investment in communication. Not so much in the machine but being able to take it to the market these innovations is a very big effort. So, we saw that a lot of what we managed to launch as innovations did not bring what we expected".

For a portion of the interviewees, the culture oriented towards a "pro-innovation attitude" that can influence the innovation adoption is a reality in their organization. For I22, the pro-innovation culture is truly clear in the organization day-to-day, as can be seen in his report: *"Yes. I am fully convinced of that. We have a commitment here to innovation indicators, putting more innovation in the market, bringing more participation in the profitability of the company"*.

On the other hand, for a few interviewees, it is not possible to identify this culture. I19 believes that *"the company is open, but it is not focused on innovating, but on continuing to deliver what it already delivers"*. I1 is a little more emphatic in his statement: *"the company is much closed. The innovation team is only in the big centers like São Paulo and Curitiba and is well distant from the day-to-day reality of the factories and slaughterhouses. So, there is no innovation culture, or incentives for employees to innovate. It is more discourse than practice"*.

5 FINAL CONSIDERATIONS

The main objective of this study was to analyze the influence of external variables and internal characteristics on innovation adoption. The analysis of the dimensions has made it possible to identify those that need to be better explored by companies and those that are already well explored, thus promoting the adoption of innovations. Among the dimensions that need to be better explored is the dimension Network Externalities. There is a certain degree of neglect in the monitoring of business partners and the stakeholders involved in the industry do not have knowledge about the innovations. Communication and cooperation between parties can lead to innovation, so there is a need to establish a stronger link and involve stakeholders more in order to obtain the benefits that can be generated.

The Competitive Environment dimension indicates a greater need to closely monitor competitors. Being immersed in a highly competitive environment creates pressure for organizations to innovate, just as their competitors do, and monitoring them can serve as a path to follow. The Legislation dimension emerged as a complex and significant issue that

impacts the adoption and there is an urgent need for action by regulatory bodies. The analysis of the Business Relationships and Key Individuals dimensions revealed that only the R&D sector is considered responsible for sharing information and knowledge internally and for having key individuals dedicated to innovation processes. However, it is necessary for all parts of the organization to see themselves as responsible and capable of adopting innovation and this needs to be better promoted within organizations. Finally, it was clear that there is no culture oriented towards a "pro-innovation attitude", focused on commitment and encouragement, and that if such a culture were implemented, it could significantly increase the success of innovation adoption.

Among the dimensions that are already well studied, it is possible to mention Innovativeness, in which the strategic posture, strategic decisions and management attitudes of firms are positively influencing innovation adoption. The Business Relationships dimension also showed a well explored side in terms of firms' partnerships with other firms, suppliers, and researchers to develop products and solutions. Inter-firm interaction and technology transfer are responsible for allowing large firms to innovate through technological advances generated by startups and small firms, an important mechanism for increasing innovation adoption.

The research presents both theoretical and practical contributions. The theoretical contributions are related to adding new perspectives to the theory of innovation adoption, especially from a Brazilian perspective. Besides that, this article contributes to reducing the literature gap regarding the alternative proteins adoption, identified in the systematic literature review conducted in article 1 of this thesis. As for the practical contributions, organizations seeking to adopt innovations can benefit from the results found in this study since it addresses the main external variables and internal characteristics that need to be considered in an innovation adoption process.

The study has its limitations. The number of interviewees is one of them, as is the fact that the study was carried out in a specific sector. For future studies we suggest expanding the number of interviewees and also carrying out the study in other sectors, in a comparative way. It is also suggested that other stakeholders be involved in addition to the organizations' managers, such as suppliers and partners, who could add new insights to the innovation adoption process. Finally, it is suggested that the study be carried out with small companies or startups, since this study only involved large companies and it is possible that the adoption process occurs differently in smaller environments, with other internal characteristics.

3 INTEGRATING RESULTS

The use of innovation adoption models can contribute to organizations by facilitating and guiding the adoption process so that they remain competitive and up-to-date in the market and create strategic differentiation (Guan et al., 2021; Sinke & Odegard, 2021). The agri-food system has its own unique characteristics and is a major contributor to the country's economy, while at the same time being traditionally considered low-tech. The sector faces several challenges due to its strong dependence on natural resources and changing consumer demands. These challenges can be solved or minimized through the innovation adoption. Thus, the proposal of an innovation adoption model for the agri-food system can bring numerous contributions to the sector (Bryant & Van der Weele, 2021; Silva et al., 2023; Klerkx & Rose, 2020; Montes de Oca Munguia, Pannell & Llewellyn, 2021).

3.1 Proposal for an Innovation Adoption Model for the Agri-food System

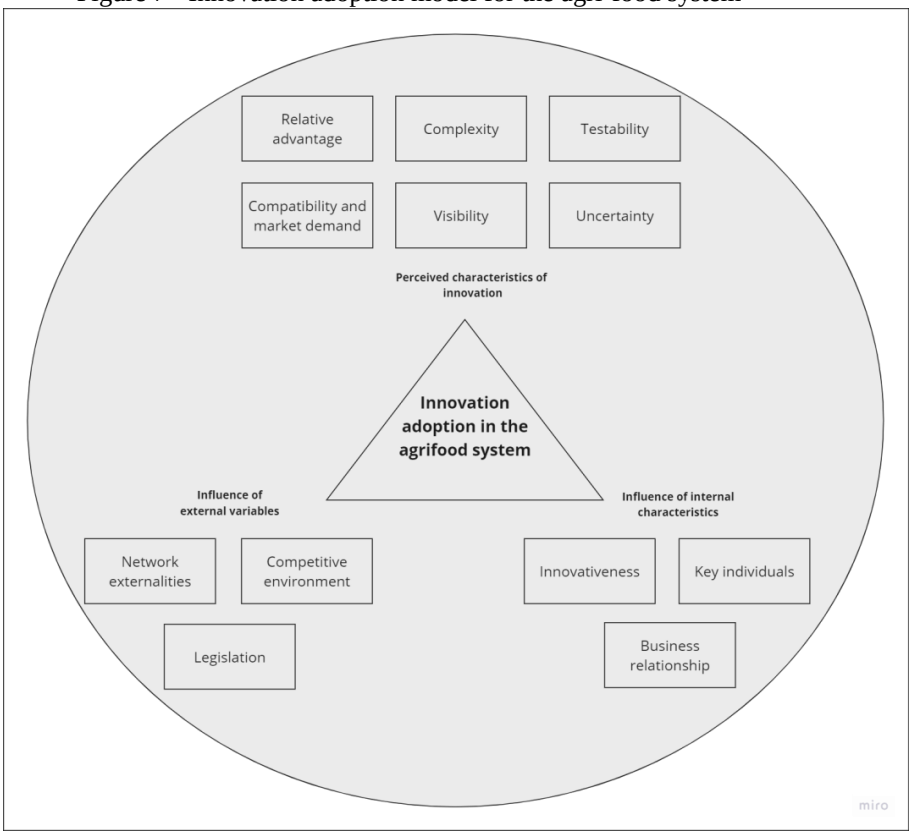
The systematic literature review conducted in article 1 of the thesis allowed to identify the main thematic gaps in the literature regarding the innovation adoption in the agri-food system and to propose future research directions. One of the gaps identified was the adoption of alternative proteins by agri-food system organizations, a promising innovation identified in the sector, and as directions for future research, the need for more in-depth studies on the topic. Therefore, alternative proteins were used as the object of study in articles 2 and 3 of this thesis, thus contributing to reducing the gap in the literature.

The three articles that make up this thesis made it possible to identify the main dimensions that influence innovation adoption in the agri-food system. These dimensions were tested with managers and leaders involved in the process of adopting alternative proteins in the agri-food system in Brazil, as presented in articles 2 and 3. These studies allowed the creation of an adoption model for the agri-food system, proposed in Figure 7.

The model starts with the perceived innovation characteristics, which represents the beliefs and perspectives of individuals embedded in the organization. They reflect attitudes toward innovation and influence the internal environment that shapes the characteristics of the organization. The perceived innovation characteristics that influence adoption by agri-food organizations are: Compatibility and Market Demand (Frambach & Schillewaert, 2002; Kabbiri et al., 2017; Rogers, 2003; Tornatzky & Klein, 1982; Venkatesh, Thong, and Xu, 2012); Relative Advantage (Damanpour & Schneider, 2009; Frambach & Schillewaert,

2002; Rogers, 2003; Tornatzky & Klein, 1982); Complexity (Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982); Testability (Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky, Fleischer & Chakrabarti, 1990; Tornatzky & Klein, 1982); Visibility (Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982); Uncertainty (Frambach & Schillewaert, 2002; Nooteboom, 1989).

Figure 7 - Innovation adoption model for the agri-food system



Source: elaborated by the author

Some dimensions that are external to the organization, guide and influence the adoption process in agri-food system and make up the model, namely: Network Externalities (Cox et al., 2002; Frambach & Schillewaert, 2002; Kastelli et al., 2016); Competitive Environment (Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti, 1990); Legislation (Bryant, 2020; Ettlie, 1983b; Morais-da-Silva et al., 2022; Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023). In addition, internal characteristics of the organization, which are diverse, influence the adoption process. In the agri-food system, those that have the most influence are: Innovativeness (Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Makkonen et al., 2016; Rogers, 2003); Business Relationship (Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse

& Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam et al., 2014; Rogers, 2003; Wairimu et al., 2022); Key Individuals (Annamalah et al., 2022; Damanpour & Schneider, 2009; Ettlie, 1983b; Makkonen et al., 2016; Wairimu et al., 2022). Table 26 compiles all the dimensions that make up the model and presents their description and the references that were used to support the analysis of each one.

Table 26 - Dimensions that composes the model

Dimensions	Description	References
1. Perceived characteristics of innovation		
1.1 Relative Advantage	Degree to which an organization considers alternative proteins better than the conventional meat, whether in economic terms, convenience, satisfaction and/or social prestige.	(Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.1 Compatibility and Market Demand	Degree to which alternative proteins are seen as consistent with potential consumers' existing values, past experiences and needs and tendency of consumers' to adopt alternative proteins.	(Frambach & Schillewaert, 2002; Kabbiri et al., 2017; Rogers, 2003; Tornatzky & Klein, 1982; Venkatesh, Thong, and Xu., 2012)
1.3 Complexity	How difficult is to members of the organization to understand how the system to produce alternative proteins works and how to use it.	(Damanpour & Schneider, 2009; Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.5 Visibility	How visible are the results of adopting alternative proteins production to the organization.	(Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky & Klein, 1982)
1.4 Testability	Degree to which the system to produce alternative proteins has been tested (even on a limited scale) by the organization; or suppliers communication is able to demonstrate the functionality of the system, create awareness and influence potential organizations' perceptions.	(Frambach & Schillewaert, 2002; Rogers, 2003; Tornatzky, Fleischer & Chakrabarti, 1990; Tornatzky & Klein, 1982)
1.6 Uncertainty	Degree of technical, financial and/or social uncertainty in adopting alternative proteins production.	(Frambach & Schillewaert, 2002; Nooteboom, 1989)
2. Influence of external variables		
2.1 Network Externalities	Degree to which business partners (organizations, competitors and/or suppliers in the agrifood system) have already adopted alternative proteins, thus increasing the innovation usefulness.	(Cox et al., 2002; Frambach & Schillewaert, 2002; Kastelli et al., 2016)
2.2 Competitive Environment	Degree to which the adoption of alternative proteins is necessary to maintain the competitive position relative to competitors in the agrifood system.	(Frambach & Schillewaert, 2002; Tornatzky, Fleischer & Chakrabarti, 1990)
2.3 Legislation	Influence of normative pressures and policies on alternative proteins adoption by organizations in the agrifood system.	(Bryant, 2020; Ettlie, 1983b; Morais-da-Silva et al., 2022; Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023)

3. Influence of internal characteristics		
3.1 Innovativeness	Degree of propensity to adopt radical innovations, given the influence of the organization's strategic decisions.	(Damanpour & Schneider, 2006; Frambach & Schillewaert, 2002; Makkonen et al., 2016; Rogers, 2003)
3.3 Key Individuals	Presence of skilled labor and human resources exclusively dedicated to innovation processes and organizational culture oriented towards the "pro-innovation attitude".	(Annamalah et al., 2022; Damanpour & Schneider, 2009; Ettlie, 1983; Makkonen et al., 2016; Wairimu et al., 2022)
3.2 Business Relationship	Degree to which organizations share information and knowledge internally and externally, are open to joint product development, create interaction networks and connections within the agrifood system and with other sectors, including technology providers, companies and competitors.	(Batterink et al., 2010; Chesbrough, 2003; Cox et al., 2002; Flipse & Van der Sanden, et al., 2013; Frambach & Schillewaert, 2002; Kastelli et al., 2016; Makkonen et al., 2016; McAdam et al., 2014; Rogers, 2003; Wairimu et al., 2022)

Source: elaborated by the author

This model differs from the others proposed in the literature as it considers the current dimensions that influence the innovation adoption in the agri-food system. The presence of the Legislation dimension in the model represents very clearly the differentiation of this approach. The current influence of this dimension on the adoption of alternative proteins is very significant and has inhibited and delayed the adoption of this innovation due to the lack of regulatory standards on the product, and this situation extends to all other innovations in the agri-food system, since this is a sector that is strongly influenced by regulatory issues related to food safety (Qiu, 2023; Singh et al., 2023; Vu, Ghadge & Bourlakis, 2023).

The Business Relationships dimension also proved to be fundamental to the adoption of alternative proteins, as it was the partnership with the startups developing the product that made it possible for organizations in Brazil to adopt the innovation. Organizations in the agri-food system have historically been considered low-tech, without large investments in R&D. Partnerships with startups and technology-based companies, as well as connections with technology providers and other sectors, are fundamental to the adoption of other innovations in this sector, so this is a dimension that cannot be neglected in adoption models for the agri-food system (Kastelli et al., 2016; Makkonen et al., 2016; Wairimu et al., 2022).

Therefore, the proposed model is a guide for organizations in the agri-food system seeking to adopt innovations. The model provides an organized approach to analyzing adoption and can be applied as a method to assess the influence of the different dimensions

that most impact agri-food system organizations in the adoption process.

4 FINAL CONSIDERATIONS

Through the studies conducted in the articles that make up this thesis, it was possible to verify that adoption models are extremely efficient for organizations as they are able to provide a structured way to analyze adoption and provide a method to study the impact of different dimensions on the adoption process (Guan et al., 2021; Sinke & Odegard, 2021). Despite the different adoption models proposed in the literature, studies dealing with adoption models in the agri-food system are scarce. Given the economic relevance of the agri-food system and the constant possibilities for innovation in the sector, the proposition of an innovation adoption model that takes into account the characteristics of the sector is relevant from an academic and marketing point of view (Bryant & Van der Weele, 2021; Silva et al., 2023; Klerkx & Rose, 2020; Montes de Oca Munguia, Pannell & Llewellyn, 2021).

The model proposed in this thesis needs to be validated by other studies. Despite this, it is a new model for the literature, which considers the reality of the agri-food system in Brazil. From an international perspective, it makes sense for Brazilian researchers to produce models for areas of national interest, since Brazil has a relevant participation in the agri-food system worldwide. The limitations of this study are due to its theoretical prerogative. Besides this, the survey of bibliographic material was complemented by interviews with twenty-nine managers, and statistical analysis was not employed, which makes it not possible to generalize the results obtained at first sight. In further research, it is recommended that these results, presented as a model proposition, be validated by statistical analysis. In this sense, it is a study of theoretical basis, with non-generalizable results and collected from a specific and small group.

Therefore, the proposed model is derived from an applied synthesis of other propositions, and its differential is its focus on the agri-food system. As such, the model shows itself, for now, to be a valid contribution between the needs of the scientific community and the needs of the market. Further studies are suggested to analyze and subsequently apply this model in loco aiming at its improvement and empirical validation.

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APPENDIX A: Impact Factor Calculation – Article 1

	Title	Authors	Publication year	Quotes 2020	Journal Impact Factor 2020	IF calculation (eq. 1)	
1	Facilitating knowledge management through filtered big data: SME competitiveness in an agri-food sector	O'Connor, C.; Kelly, S.	2017	19	8182	155477	**Selected after application of Pareto (80%)**
2	A novel view on knowledge sharing in the agri-food sector	Fait, M.; Scorrano, P.; Mastroleo, G.; Cillo, V.; Scuotto, V.	2019	17	8182	139111	
3	Mobile phone adoption in agri-food sector: Are farmers in Sub-Saharan Africa connected?	Kabbiri, R.; Dora, M.; Kumar, V.; Elepu, G.; Gellynck, X.	2018	11	8593	94534	
4	Orchestrating innovation networks: The case of innovation brokers in the agri-food sector	Batterink, M. H.; Wubben, E. F. M.; Klerkx, L.; Omta, S. W. F.	2010	18	5149	92700	
5	An examination of product innovation in low- and medium-technology industries: Cases from the UK packaged food sector	Trott, P.; Simms, C.	2017	9	8110	72999	
6	Many or trusted partners for eco-innovation? The influence of breadth and depth of firms' knowledge network in the food sector	Gonzalez-Moreno, A.; Triguero, A.; Saez-Martinez, F. J.	2019	8	8593	68752	
7	A knowledge management approach to organizational competitive advantage: Evidence from the food sector	Massa, S.; Testa, S.	2009	12	5075	60912	
8	A resilient social economy? Insights from the community food sector in the UK	Sonnino, R.; Griggs-Trevarthen, C.	2013	7	5149	36050	
9	Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology?	Matin, A. H; Goddard, E.; Vandermoere, F.; Blanchemanche, S.; Bieberstein, A; Marette, S.;	2012	8	3864	30920	

		Roosen, J.					
10	Technology transfer as a mechanism for dynamic transformation in the food sector	Kastelli, I.; Tsakanikas, A.; Caloghirou, Y.	2018	5	5783	28920	
11	Development of small and medium-sized enterprise horizontal innovation networks: UK agri-food sector study	McAdam, M.; McAdam, R.; Dunn, A.; McCall, C.	2014	4	5473	21896	
12	Improving industrial R&D practices with social and ethical aspects: Aligning key performance indicators with social and ethical aspects in food technology R&D	Flipse, S. M.; Van der Sanden, M. C. A.; Osseweijer, P.	2014	2	8593	17188	
13	Evaluation and design of innovation policies in the agri-food sector: An application of multilevel self-regulating agents	Gagliardi, D.; Niglia, F.; Battistella, C.	2014	1	8593	8594	
14	Knowledge sources and integration ties toward innovation. A food sector perspective	Toselli, M.	2017	2	3500	7002	
15	Innovation spells in the multinational agri-food sector	Alfranca, O; Rama, R; Von Tunzelmann, N.	2004	1	6606	6607	
16	Sanitizing agri-food tech: COVID-19 and the politics of expectation	Reisman, E.	2021	1	6512	6513	
17	3D printed food attributes and their roles within the value-attitude-behavior model: Moderating effects of food neophobia and food technology neophobia	Lee, K. H.; Hwang, K. H.; Kim, M.; Cho, M.	2021	1	5959	5960	
18	The role of discourse in the quest for low-carbon economic practices: A case of standard development in the food sector	Bonnedahl, K. J.; Eriksson, J.	2011	1	5075	5076	
19	The challenge of introducing low-carbon industrial practices: Institutional entrepreneurship in the agri-food sector	Stal, H. I.; Bonnedahl, K. J.; Eriksson, J.	2014	1	5075	5076	
20	A note on the relationship between managerial change values, innovative intentions, and	Ettlie, J. E.	1983	1	4272	4273	

	innovative technology outcomes in food sector firms						
21	The level of management maturity in the Polish food sector and its relation to financial performance	Kafel, P.; Sikora, T.	2014	1	3824	3825	
22	Improving logistics efficiency of industrial districts: a framework and case study in the food sector	Bottani, E.; Rizzi, A.; Vignali, G.	2015	1	3821	3822	
23	Toward solutions for food crisis in the 21st century - From basic research to development of innovative food technologies	Mitsuda, H	1999	1	3493	3494	
24	Opening up innovation processes through contests in the food sector	Massa, S.; Testa, S.	2017	1	3464	3465	
25	Identifying key performance indicators in food technology contract R&D	Flipse, S M.; Van der Sanden, M C. A.; Van der Velden, T; Fortuin, F. T. J. M.; Omta, S. W. F.; Osseweijer, P.	2013	1	3347	3348	
26	The firm in the Information Age: organizational responses to technological change in the processed foods sector	Cox, H; Mowatt, S.; Prevezer, M.	2002	1	3085	3086	
27	Innovation in the Agri-food sector: Exploiting opportunities for Industry 4.0	Oltra-Mestre, M. J.; Hargaden, V; Coughlan, P; Segura-Garcia del Rio, B.	2021	1	3051	3052	**Discarded after applying Pareto (20%)**
28	E-Commerce in Agri-food Sector: A Systematic Literature Review Based on Service-Dominant Logic	Zhang, M.; Berghall, S.	2021	1	3049	3050	
29	The Role of Social Media in the Innovation and Performance of Kuwaiti Enterprises in the Food Sector	Alhaimer, R. S.	2021	1	3049	3050	
30	Facilitating collaborative priority-setting for research and innovation: a case from the food sector	Brattstrom, E.	2021	1	2874	2875	

31	Comparing voluntary sustainability initiatives and product carbon footprint in the food sector, with a particular focus on environmental impacts and developing countries	Plassmann, K.	2018	1	1649	1650	
32	Transformation of the agri-food sector: Lessons from the Caribbean	Andreatta, S.	1998	2	0,833	3,7	
33	Modern food-technology: industrializing nature	Sorj, B; Wilkinson, J.	1985	2	0,14	2,3	
34	Advances in food technology and its social implications	Pyke, M.	1970	0	0	0	**Discarded for not having JCR**
35	Supply chain issues in SME food sector: a systematic review	Jose, A; Shanmugam, P. V.	2019	2	0	2	
36	SME network relationships and competitive strategies in the agri-food sector Some empirical evidence and a provisional conceptual framework	Camanzi, L.; Giua, C.	2020	2	0	2	
37	Achieving Sustainable Development Goals in the global food sector: A systematic literature review to examine small farmers engagement in contract farming	Vamuloh, V. V.; Panwar, R.; Hagerman, S. M; Gaston, C.; Kozak, R. A.	2019	1	0	1	
38	Opportunities and challenges in the e-commerce of the food sector	Vargas, V. M.; Budz, S.	2019	1	0	1	
39	Determining Factors of Voluntariness in Sustainable Environmental Innovation (Eco-Processes) and Their Certification: Agri-food Sector	Carrillo, R.; Fort, F.; Parras R. M; Murgado, E. M.	2017	1	0	1	
40	Innovation in family businesses: a case study in the food sector	Dana, Leo-Paul; G. E; Culasso, F.; Stupino, M.	2014	1	0	1	
41	Efficiency-Focused Economic Modeling of Competitiveness in The Agri-food Sector	Bezat-Jarzebowska, A.; Rembisz, W.	2013	0	0	0	
42	Implication of TNCs in agri-food sector - challenges, constraints, and limits - profit or CSR?	Panait, M.; Erokhin, V.; Andre, J.; Gao, T.	2020	0	0	0	

43	Training and Development from the management's viewpoint: a case study in the food sector	Gil, E. P.; Hoeckesfeld, L; Silva, L. H.; Drozdek P, C. M.	2020	0	0	0	
44	Intra-functional coordination: the case of purchasing during innovation in the agri-food sector	Viale, L.	2019	0	0	0	
45	Analysis and design of products traceability in agri-food sector based on RFID technology	Tudora, E.; Alexandru, A.; Tirziu, E.	2017	0	0	0	
46	Measuring the intensity of innovation in the Brazilian food sector: a DEA-Malmquist approach	Cappellesso, G.; Raimundo, C. M.; Thome, K. M.	2020	0	0	0	
47	Packaging Dependent Products: How do Firms in the Packaged Food Sector Manage the Development of new Packaging Opportunities?	Simms, C.; Trott, P.	2017	0	0	0	
48	Backcasting as an approach to creating long-term development strategies for the agri-food sector	Wieliczko, B.	2017	0	0	0	
49	Technological Tools Integration and Ontologies for Knowledge Extraction from Unstructured Sources: A Case of Study for Marketing in Agri-food Sector	Caione, A; Paiano, R.; Guido, A. L.; Fait, M.; Scorrano, P.	2013	0	0	0	
50	Taste a bit!!!: some (advanced) conclusions about the sociological impact of Food Tech	Scribano, A.	2021	0	0	0	
51	Climate Change's Impact on Pakistani Agriculture and Food Sector: Media Reporting and Its Analysis	Yang, H.; Riaz, M. Mr; Javed, M. N.; Madni, A. R; Cheng, Y.	2021	0	0	0	
52	Innovation policy in the agri-food sector: evidence from undeveloped Mexican regions	Solis-Navarrete, J. A.; Bucio-Mendoza, S.; Mata-Vazquez, P.; Astudillo-Miller, M. X.	2021	0	0	0	
53	Innovation in the food sector: modeling the future of food security	Bobe, M.; Toma, M. A; Bumbac, R.; Jurconi, A.	2020	0	0	0	
54	The concept of Collaborative Innovation with Customers and its significance for creating innovations in the food sector	Liczmanska-Kopcewicz, K.	2020	0	0	0	

55	Coopetition enterprises of agri-food sector in the region underdeveloped economically	Nasalski, Z.	2019	0	0	0	
56	Increasing the performance of the organic food sector in the European Union by using innovative instruments	Pamfilie, R.; Toma, M. A.	2019	0	0	0	
57	Innovation management in family microenterprises of the food sector in Jipijapa	Pena, P; Diana, K.; Baque, C; Miguel, A.; Fernandez, C. R. R.	2018	0	0	0	
58	Specialization in the food sector in Poland in an aspect of implementation of a new development pathway	Firlej, K.; Firlej, C.	2018	0	0	0	
59	Changeover time reduction through lean tool SMED: a case study from food sector	Galova, K.	2018	0	0	0	
60	Responsible consumption in food sector. Case study: Fairtrade	La Sara, L.; Fiorani, G.; Litardi, Irene	2017	0	0	0	
61	Critical factors for risk reduction in the Serbian agri-food sector	Mihailovic, B.; Vukovic, P.	2017	0	0	0	
62	Small scale organic farmers - source of growth in the Bosnia and Herzegovina agri-food sector	Mujcinovic, A.; Nikolic, A.; Uzunovic, M.	2017	0	0	0	
63	An overview on properties and usage of nanostructured materials in the food sector	Safaei, M; Karimi, N; Alavi, M; Taran, M; Rezaei, R.	2017	0	0	0	
64	Logistic attitude and Behavior in export: Case of a Moroccan SMEs in the Agri-food Sector	Abakouy, M.; Housni, H.	2016	0	0	0	
65	Impact of Research on Development in Cameroon: convergence between supply and research needs in the food sector	Minkoua, J. R.; Temple, L.	2016	0	0	0	
66	Food science and food-technology in Thailand	Thunpithayakul, C.; Chittapron, P.	1979	0	0	0	

APPENDIX B: Interview Script – Article 2

The goal of this interview is to evaluate dimensions that influence the innovation adoption for alternative proteins, considering that adoption is the decision to make use of an innovation as the best course of action available (Rogers, 2003).

The alternative proteins considered in this study are vegetable or plant-based meat, fermentation-based meat, and cultured meat. Vegetable or plant-based meat is a food made from plants and vegetables and has no ingredients of animal origin. The cultured meat, in a simplified way, is a food made by a process that begins with the biopsy of the animal, where stem cells are removed and later placed in a culture medium, in bioreactors that reproduce the animal system, nourishing the cell so that it can multiply. The fermentation-based meat uses the precision fermentation process to leverage microbial hosts as cell factories. Thus, instead of using plant proteins, proteins from filamentous fungi, mycelium and fungal biomass are used as the basis for fermentation-based meats (Barbosa, 2017; GFI, 2022b, 2022a; Guan et al., 2021).

Identification questions

1. Location and date of interview
2. Company's name and department
3. Interviewee's name and title
4. Period working at the company

About the company

1. In which countries does the organization operate?
2. How many employees the organization have?

General questions

1. What is your company's main product or service?
2. Has your company adopted the production/sale of alternative proteins? If yes, since when? If not, are there plans for adoption?
3. In your opinion, what are the factors that influence the adoption (or rejection) of alternative proteins by your company?

Script

For companies that have already adopted alternative proteins

Q1. In your opinion, what are the future market prospects and adoption trends for alternative proteins?
Q2. How has been the company's experience with the adoption of alternative proteins so far?
Q3. Do you believe that the adoption of alternative proteins by your company brought benefits and advantages to your company (whether in economic terms, convenience, satisfaction and/or social prestige)?

Q4. Do you believe that the adoption of alternative proteins by your company brought any disadvantages to your company? If yes, which ones?
Q5. What is the complexity for your company to adopt alternative proteins? It required (or still requires) many adjustments for production/sale and product development?
Q6. How was the testing phase for the adoption of alternative proteins? Do you think that this influenced the adoption in any way?
Q7. Has the adoption of alternative proteins by your organization brought visible results for the company? If yes, which ones?
Q8. In your opinion, what is the uncertainty level of the alternative protein market (whether from a technical, financial and/or social point of view)?

For companies that have NOT adopted alternative proteins yet

Q1. In your opinion, what are the future market prospects and adoption trends for alternative proteins?
Q2. Has your company had any experience with alternative proteins?
Q3. Do you believe that the adoption of alternative proteins by your company could bring benefits and advantages to your company, in the medium or long term (whether in economic terms, convenience, satisfaction and/or social prestige)?
Q4. Do you believe that the adoption of alternative proteins by your company could bring any disadvantages to your company? If yes, which ones?
Q5. What is the complexity for your company to adopt alternative proteins? It would require many adjustments for production/sale and product development?
Q6. Has your company already carried out some type of tests for the production of alternative proteins, or has a supplier already presented related inputs and equipment? Do you think that influenced the adoption decision in any way?
Q7. Do you believe that the adoption of alternative proteins by your organization could bring some kind of visible results for the company, in the medium or long term? If yes, which ones?
Q8. In your opinion, what is the uncertainty level of the alternative protein market (whether from a technical, financial and/or social point of view)?

APPENDIX C: Explanation of the Interview Script – Article 2

This Appendix presents a table that explains how the interview script for article 2 was defined, and the relation between the questions and each variable of the model.

	For companies that have already adopted alternative proteins	**For companies that have not adopted alternative proteins yet**
1. Perceived characteristics of the innovation	**Interview Script – Article 2**	
1.1 Compatibility and market demand	Q1. In your opinion, what are the future market prospects and adoption trends for alternative proteins?	
	Q2. How has been the company's experience with the adoption of alternative proteins so far?	Q2. Has your company had any experience with alternative proteins?
1.2 Relative or economic advantage	Q3. Do you believe that the adoption of alternative proteins by your company brought benefits and advantages to your company (whether in economic terms, convenience, satisfaction and/or social prestige)?	Q3. Do you believe that the adoption of alternative proteins by your company could bring benefits and advantages to your company, in the medium or long term (whether in economic terms, convenience, satisfaction and/or social prestige)?
	Q4. Do you believe that the adoption of alternative proteins by your company brought any disadvantages to your company? If yes, which ones?	Q4. Do you believe that the adoption of alternative proteins by your company could bring any disadvantages to your company? If yes, which ones?
1.3 Complexity	Q5. What is the complexity for your company to adopt alternative proteins? It required (or still requires) many adjustments for production/sale and product development?	Q5. What is the complexity for your company to adopt alternative proteins? It would require many adjustments for production/sale and product development?
1.4 Testability	Q6. How was the testing phase for the adoption of alternative proteins? Do you think that this influenced the adoption in any way?	Q6. Has your company already carried out some type of tests for the production of alternative proteins, or has a supplier already presented related inputs and equipment? Do you think that influenced the adoption decision in any way?
1.5 Visibility	Q7. Has the adoption of alternative proteins by your organization brought visible results for the company? If yes, which ones?	Q7. Do you believe that the adoption of alternative proteins by your organization could bring some kind of visible results for the company, in the medium or long term? If yes, which ones?
1.6 Uncertainty	Q8. In your opinion, what is the uncertainty level of the alternative protein market (whether from a technical, financial and/or social point of view)?	

APPENDIX D: Interview Script – Article 3

The goal of this interview is to evaluate dimension that influence the innovation adoption for alternative proteins, considering that adoption is the decision to make use of an innovation as the best course of action available (Rogers, 2003). The alternative proteins considered in this study are vegetable or plant-based meat, fermentation-based meat, and cultured meat.

Vegetable or plant-based meat is a food made from plants and vegetables and no ingredients of animal origin (Barbosa, 2017; GFI, 2021). The cultured meat, in a simplified way, is a food made by a process that begins with the biopsy of the animal, where stem cells are removed and later placed in a culture medium, in bioreactors that reproduce the animal system, nourishing the cell so that it can multiply (GFI, 2022a; Guan et al., 2021). The fermentation-based meat uses the precision fermentation process to leverage microbial hosts as cell factories. Thus, instead of using plant proteins, proteins from filamentous fungi, mycelium and fungal biomass are used as the basis for fermentation-based meats (GFI, 2022b; Meati Inc., 2022; Mycorena, 2022).

Identification questions

5. Location and date of interview
6. Company's name and department
7. Interviewee's name and title
8. Period working at the company

About the company

3. In which countries does the organization operate?
4. How many employees the organization have?

General questions

4. What is your company's main product or service?
5. Has your company adopted the production/sale of alternative proteins? If yes, since when? If not, are there plans for adoption?
6. In your opinion, what are the factors that influence the adoption (or rejection) of alternative proteins by your company?

Script

For companies that have already adopted alternative proteins

Q1. Have your company's primary business partners (stakeholders, organizations and/or suppliers) adopted alternative proteins? If yes, which one of them? If not, what do you think could be the causes of non-adoption?

Q2. Have your direct and indirect competitors embraced alternative proteins? If yes, can you name some of them?

Q3. Do you think that the adoption or the non-adoption by your competitors affect your company? If yes, how?
Q4. Is there any regulatory pressure that has influenced (or still influences) the adoption of alternative proteins, whether positively or negatively?
Q5. Do you believe that your organizations strategic posture positively influences the adoption of alternative proteins? How?
Q6. Do you consider that your organization shares information and knowledge internally and is open to joint product development?
Q7. Does your organization participate in networks of interaction and connections within the agri-food system and with other sectors, including technology providers, companies, and competitors?
Q8. In your company, can you identify the presence of human resources exclusively dedicated to innovation processes?
Q9. In your company, is there an organizational culture oriented towards a "pro-innovation attitude"? Do you think that this can influence the innovation adoption?

For companies that have NOT adopted alternative proteins yet

Stage 2
Q1. Have your company's primary business partners (stakeholders, organizations and/or suppliers) adopted alternative proteins? If yes, which one of them? If not, what do you think could be the causes of non-adoption?
Q2. Have your direct and indirect competitors embraced alternative proteins? If yes, can you name a few?
Q3. Do you think that the adoption or the non-adoption by your competitors affect your company? If yes, how?
Q4. Is the fact that your company has not adopted alternative proteins so far related to any regulatory pressure?
Q5. Do you believe that your organizations strategic posture positively influences the adoption of alternative proteins? How?
Q6. Do you consider that your organization shares information and knowledge internally and is open to joint product development?
Q7. Does your organization participate in networks of interaction and connections within the agri-food system and with other sectors, including technology providers, companies, and competitors?
Q8. In your company, can you identify the presence of human resources exclusively dedicated to innovation processes?
Q9. In your company, is there an organizational culture oriented towards a "pro-innovation attitude"? Do you think that this can influence the innovation adoption?

APPENDIX E: Explanation of the Interview Script – Article 3

This Appendix presents a table that explains how the interview script for article 3 was determined, and the relation between the questions and each variable of the model.

<table>
<tr><th></th><th>For companies that have already adopted alternative proteins</th><th>For companies that have not adopted alternative proteins yet</th></tr>
<tr><td>1. Influence of external variables</td><td colspan="2">Interview Script - Article 3</td></tr>
<tr><td>1.1 Network externalities</td><td colspan="2">Q1. Have your company's primary business partners (stakeholders, organizations and/or suppliers) adopted alternative proteins? If yes, which one of them? If no, what do you think could be the causes of non-adoption?</td></tr>
<tr><td rowspan="2">1.2 Competitive environment</td><td colspan="2">Q2. Have your direct and indirect competitors embraced alternative proteins? If yes, can you name a few?</td></tr>
<tr><td colspan="2">Q3. Do you think that the adoption or the non-adoption by your competitors affect your company? If yes, how?</td></tr>
<tr><td>1.3 Legislation</td><td>Q4. Is there any regulatory pressure that has influenced (or still influences) the adoption of alternative proteins, whether positively or negatively?</td><td>Q12. Is the fact that your company has not adopted alternative proteins so far related to any regulatory pressure?</td></tr>
<tr><td colspan="3">2. Influence of internal characteristics</td></tr>
<tr><td>2.1 Innovativeness</td><td colspan="2">Q5. Do you believe that your organizations strategic posture positively influences the adoption of alternative proteins? How?</td></tr>
<tr><td rowspan="2">2.2 Business relationship and interconnectedness</td><td colspan="2">Q6. Do you consider that your organization shares information and knowledge internally and is open to joint product development?</td></tr>
<tr><td colspan="2">Q7. Does your organization participate in networks of interaction and connections within the agri-food system and with other sectors, including technology providers, companies, and competitors?</td></tr>
<tr><td rowspan="2">2.3 Key individuals</td><td colspan="2">Q8. In your company, can you identify the presence of human resources exclusively dedicated to innovation processes?</td></tr>
<tr><td colspan="2">Q9. In your company, is there an organizational culture oriented towards a “pro-innovation attitude”? Do you think that this can influence the innovation adoption?</td></tr>
</table>

APPENDIX F: Interviewees Information – Articles 2 and 3

Identification	Respondent	Title/Position	Company	Company time
I1	M.A.	Processes and Control supervisor	C1	1 year, 5 months
I2	B.R.G.	Supervising engineer	C2	1 year, 5 months
I3	E.F.	Systems Coordinator	C3	2 years, 10 months
I4	F.J.S.	Production manager	C2	2 years, 6 months
I5	F.M.S.	Specialist in Strategy and Innovation	C4	1 year, 10 months
I6	I.C.D.	Quality Control Manager	C5	10 years
I7	J.A.	Purchasing and Supply Manager	C7	2 years, 2 months
I8	F.C.P.	Executive Manager of R&D and Innovation	C1	5 years
I9	C.F.	Executive Innovation Marketing Manager	C1	12 years, 7 months
I10	B.B.	R&D Specialist	C1	1 year, 3 months
I11	W.V.S.	Industrial director	C4	8 months
I12	P.T.	International procurement and sales manager	C6	9 years, 10 months
I13	L.A.	Quality Assurance Manager	C2	1 year
I14	E.F.A.	Product Inspection Department Manager	C5	3 years, 9 months
I15	C.H.	Logistics Manager	C5	10 years
I16	T.Z.	B2B E-Commerce Executive Manager	C1	6 years, 6 months
I17	M.A.M.	Production coordinator	C2	15 years, 7 months
I18	L.S.V.	Industrial manager	C2	1 year, 6 months
I19	E.F.	R&D Manager	C6	5 years
I20	V.S.T.	Insights & Performance Manager	C1	7 years, 9 months
I21	E.O.R.	Innovation Manager	C1	6 years, 2 months
I22	R.F.J.	Innovation Specialist	C5	1 years, 6 months
I23	F.F.	Research Development executive	C1	7 years, 1 month
I24	R.F.N.	Senior Innovation and New Business Analyst	C6	2 years
I25	L.P.	R&D Specialist	C2	4 years, 4 months
I26	G.C.M.	Innovation Sr Manager	C3	11 months
I27	M.L.S.M.	Commercial Coordinator	C7	8 years, 7 months
I28	L.N.P.	R&D and Business Management Manager	C4	5 years
I29	E.M.G.R.	R&D Coordinator	C2	5 years, 1 month

APPENDIX G: Consent Form – Articles 2 and 3

You have been invited to take part in the research entitled *Innovation Adoption in the Agri-food System: A Model Proposition* because you work in roles linked to the agri-food system in Brazil. The researcher in charge of the research is Marcela Naves Costa Ribeiro, government-issued ID Number xxxxxxxxx, PhD student in Administration at FEA-USP. The goal for this research is to offer a model that identifies the elements that constitute the adoption of innovation for alternative proteins to meat, contributing to the agri-food system and its components, and bringing clarification on the subject.

As you share your perception and experience regarding the adoption of innovations in companies of the agri-food system, specially the adoption of alternative proteins to meat, you will aid the researcher to better understand this phenomenon. As for the risks you may be exposed to, these are inherent to the interview, such as:

- Tiredness and discomfort: minimal risk; to reduce it, we recommend choosing a comfortable and quiet place to attend the interview, in addition to being able to request breaks, if needed.

- Possibility of embarrassment when answering a question: minimal risk; mitigated by the possibility of not answering questions you do not want to, without any harm.

- Stress, including the fact that the video call is used; and if you have technical problems that make it impossible for you to continue, you can interrupt the interview and reschedule it, according to your availability or simply end it without rescheduling, without any judgement.

- Breach of confidentiality and anonymity, due to the possibility of loss or undue exposure of the video call recording: maximum degree risks; minimized by the fact that only the researcher and her advisor have access to the recordings, care will be taken with safe storage and as soon as the interviews are transcribed, the image and voice recording files will be destroyed. You can still refuse to participate or request the deletion of data, even if the interview has already taken place.

As a research participant and according to Brazilian law, you have several rights, in addition to anonymity, confidentiality, secrecy and privacy, even after the end or interruption of the research. Thus, you are guaranteed:

- The observance of the practices determined by the applicable legislation, including Resolutions 466 (and, in particular, its item IV.3) and 510 of the National Health Board (*Conselho Nacional de Saúde*), which governs research ethics and this Term.

- The full freedom to decide on their participation without any prejudice or reprisal of any kind.

- The full freedom to withdraw your consent at any stage of the research, without prejudice or reprisal of any kind. In this case, the data collected from your participation up to the time of withdrawal of consent will be discarded unless otherwise explicitly authorized by you.

- Full and immediate monitoring and assistance, even after the termination or interruption of the research, free of charge, for as long as necessary, whenever required and related to your participation in the research, upon request to the main researcher.

- Access to research results.

- Reimbursement of any expenses related to participation in the research (for example, cost of transportation to the agreed place for the interview), including any companion, upon request to the main researcher.

- Compensation for any damage resulting from the research.

- Access to this document. This document is initialed and signed by you and a researcher from the research team, in two copies, one of which will remain with you. If you lose your copy, you may also request a copy of the document from the main researcher.

During the entire period of the research or after its completion, you have the right to request any type of clarification by contacting the main researcher, by emailing marcela.xxx@usp.br, calling (35) 9xxxx-xxxx, contacting in person or by post to Rua xxxxxxx, São Paulo - SP, CEP: xxxxx-xxx.

If you choose to participate in the research, you are required to state your consent verbally or in writing at the time of the interview by saying: "I, (your full name), freely and knowledgeably declare that I agree to participate in the research as established in this TERM."

If you choose to allow the recording of the videoconference, you are required to state your consent verbally or in writing at the time of the interview by saying: "I, (your full name), freely and knowledgeably declare that I accept the recording of the videoconference for academic purposes".