INNOVATION ADOPTION IN THE AGRI-FOOD SYSTEM: A SYSTEMATIC LITERATURE REVIEW CONSIDERING SUSTAINABLE INNOVATIONS

Autoria

Marcela Naves Costa Ribeiro - marcela.naves.ribeiro@usp.br
Prog de Pós-Grad em Admin/Faculdade de Economia, Admin e Contab – PPGA/FEA / USP - Universidade de São Paulo

Eduardo Pinheiro Gondim de Vasconcellos - epgdvasc@gmail.com
Prog de Pós-Grad em Admin/Faculdade de Economia, Admin e Contab – PPGA/FEA / USP - Universidade de São Paulo

Andrea Aparecida da Costa Mineiro - andreamineiro@uol.com.br
Programa de Pós-Graduação em Administração – PPGA / UFLA - Universidade Federal de Lavras

Resumo

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 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 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 and 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.

INNOVATION ADOPTION IN THE AGRI-FOOD SYSTEM: A SYSTEMATIC LITERATURE REVIEW CONSIDERING SUSTAINABLE INNOVATIONS

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 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 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 and 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 to be 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).

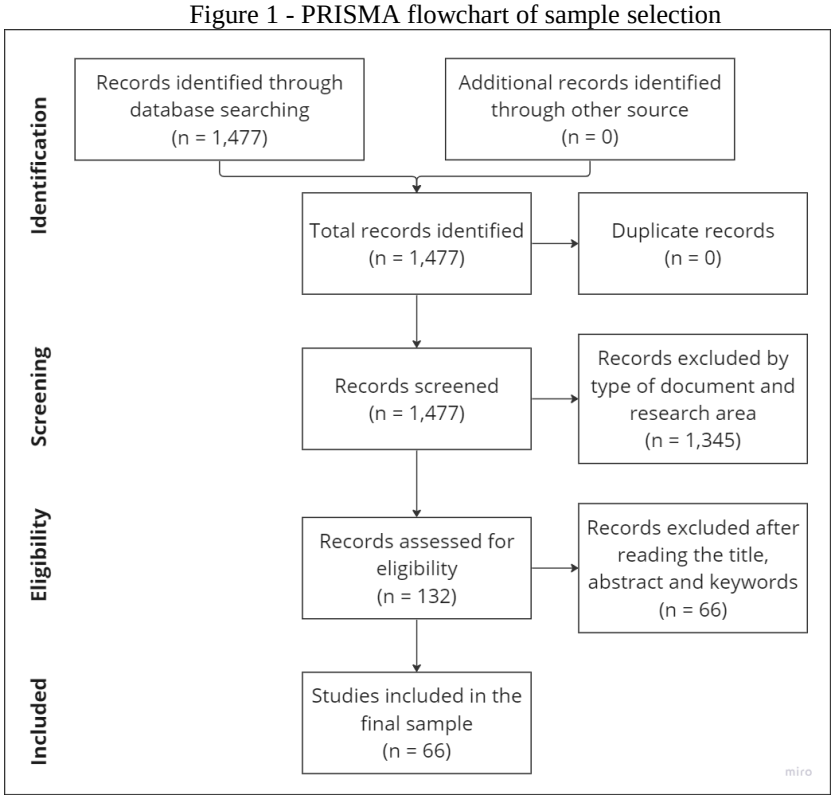
i) Delimitation and framing of the question: Despite the possibilities of competitive advantage and growth that innovations can generate for the agri-food system, organizations in the sector face many limitations, such as lack of technical knowledge about innovations, low incentives to innovate, among 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 1 - 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 1 - 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 2 - 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 - Small and Medium-Sized Enterprises. 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 2 - 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 3 - 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 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 concerns the influence of managers and the skills they develop to identify and support innovation in 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, thus strengthening the organization's capacity for networked innovation processes within the organization (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 innovation adoption 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 4 - 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 innovation and start producing 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 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.

References

ABAG, A. B. A. (2020). *Visão da Inovação e da Competitividade do Agronegócio*. Retrieved from: https://abag.com.br/wp-content/uploads/2023/03/position-paper-abag-2023.pdf

Alfranca, O., Rama, R., & Von Tunzelmann, N. (2004). Innovation spells in the multinational agri-food sector. *Technovation*, *24*(8), 599–614. doi: 10.1016/S0166-4972(02)00129-3

Ali, A., Jiang, X., & Ali, A. (2022). Social ties, absorptive capacity, and the adoption of green innovation: a social capital perspective. *International Journal of Manpower*, *44*(2), 214–230. doi: 10.1108/IJM-10-2021-0597

Bardin, L. (2004). *Análise de conteúdo*. 3rd ed. Lisboa: Edições 70.

Bardin, L. (2016). *Análise de Conteúdo*. Lisboa: Edições 70.

Batterink, M. H., Wubben, E. F. M., Klerkx, L., & Omta, S. W. F. (2010). Orchestrating innovation networks: the case of innovation brokers in the agri-food sector. *Entrepreneurship and Regional Development*, *22*(1). doi: 10.1080/08985620903220512

Bimbo, F., Bonanno, A., Nocella, G., Viscecchia, R., Nardone, G., De Devitiis, B., & Carlucci, D. (2017). Consumers' acceptance and preferences for nutrition-modified and functional dairy products: a systematic review. *Appetite*, *113*, 141–154. doi: 10.1016/j.appet.2017.02.031

Bonnedahl, K. J., & Eriksson, J. (2011). The role of discourse in the quest for low-carbon economic practices: a case of standard development in the food sector. *European Management Journal*, *29*(3), 165–180. doi: 10.1016/j.emj.2010.10.008

Botelho, L. L. R., Cunha, C. C. de A., & Macedo, M. (2011). O método da revisão integrativa nos estudos organizacionais. *Gestão e Sociedade*, *5*(11), 121. doi: 10.21171/ges.v5i11.1220

Bottani, E., Rizzi, A., & Vignali, G. (2014). Improving logistics efficiency of industrial districts: a framework and case study in the food sector. *International Journal of Logistics Research and Applications*, *18*(5), 402–423. doi: 10.1080/13675567.2014.945401

Bryant, C. J., & Van der Weele, C. (2021). The farmers' dilemma: meat, means, and morality. *Appetite*, *167*(April). doi: 10.1016/j.appet.2021.105605

Carvalho, M. M., Fleury, A., & Lopes, A. P. (2013). An overview of the literature on technology roadmapping (TRM): contributions and trends. *Technological Forecasting and Social Change*, *80*(7), 1418–1437. doi: 10.1016/j.techfore.2012.11.008

Castillo-Acobo, R. Y. et al. (2022). The Role of Innovation Adoption and Circular Economy Readiness on the Environmental Sustainability: Moderating Impact of Organizational Support. *AgBio Forum*, *24*(2), 115–235. https://agbioforum.org/menuscript/index.php/agb/article/view/156

Chesbrough, H. (2007). Business model innovation: It's not just about technology anymore. *Strategy and Leadership*, *35*(6), 12–17. doi: 10.1108/10878570710833714

Chuttur, M. (2009). Overview of the Technology Acceptance Model: origins , developments and future directions. *Sprouts: Working Papers on Information Systems*, *9*(37), 1–23. doi: 10.1021/jf001443p

Cox, D. N., & Evans, G. (2008). Construction and validation of a psychometric scale to measure consumers' fears of novel food technologies: The food technology neophobia scale. *Food Quality and Preference*, *19*(8), 704–710. doi: 10.1016/j.foodqual.2008.04.005

Cox, H., Mowatt, S., & Prevezer, M. (2002). The firm in the Information Age: organizational

responses to technological change in the processed foods sector. *Industrial and Corporate Change*, *11*(1), 135–158. doi: 10.1093/icc/11.1.135

Silva, A. R., Cirani, C. B. S., Serra, F. A. R., Pigola, A., Costa, P. R., Scafuto, I. C., Ruas, R. L., & Mazieri, M. R. (2023). Determining factors on green innovation adoption: an empirical study in brazilian agribusiness firms. *Sustainability*, *15*(7). doi: 10.3390/su15076266

Damanpour, F., & Schneider, M. (2006). Phases of the adoption of innovation in organizations: Effects of environment, organization and top managers. *British Journal of Management*, *17*(3), 215–236. doi: 10.1111/j.1467-8551.2006.00498.x

Davis, J. H., & Goldberg, R. A. (1957). *A concept of agribusiness*. Eastford - Connecticut: Martino fine Books.

Doelman, J. C., Stehfest, E., Tabeau, A., & Van Meijl, H. (2019). Making the Paris agreement climate targets consistent with food security objectives. *Global Food Security*, *23*(April), 93–103. doi: 10.1016/j.gfs.2019.04.003

Ettlie, J. E. (1983a). A note on the relationship between managerial change values, innovative intentions and innovative technology outcomes in food sector firms. *R&D Management*, *13*(4), 231–244. doi: 10.1111/j.1467-9310.1983.tb00022.x

Ettlie, J. E. (1983b). Policy implications of the innovation process in the U.S. food sector. *Research Policy*, *12*(5), 239–267. doi: 10.1016/0048-7333(83)90018-5

Fait, M., Scorrano, P., Mastroleo, G., Cillo, V., & Scuotto, V. (2019). A novel view on knowledge sharing in the agri-food sector. *Journal of Knowledge Management*, *23*(5), 953–974. doi: 10.1108/JKM-09-2018-0572

Flipse, S. M., Van der Sanden, M. C. A., & Osseweijer, P. (2013). Improving industrial R&D practices with social and ethical aspects: Aligning key performance indicators with social and ethical aspects in food technology R&D. *Technological Forecasting and Social Change*, *85*, 185–197. doi: /10.1016/j.techfore.2013.08.009

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). Identifying key performance indicators in food technology contract R&D. *Journal of Engineering and Technology Management*, *30*(1), 72–94. doi: 10.1016/j.jengtecman.2012.11.003

Gerhardt, C., Suhlmann, G., Ziemßen, F., Donnan, D., Warschun, M., & Kühnle, H. J. (2020). How will cultured meat and meat alternatives disrupt the agricultural and food industry? *Industrial Biotechnology*, *16*(5), 262–270. doi: 10.1089/ind.2020.29227.cge

González-Moreno, Á., Triguero, Á., & Sáez-Martínez, F. J. (2019). Many or trusted partners for eco-innovation? The influence of breadth and depth of firms' knowledge network in the food sector. *Technological Forecasting and Social Change*, *147*(July 2018), 51–62. doi: 10.1016/j.techfore.2019.06.011

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact - The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122. doi: 10.1016/j.ecolecon.2012.04.005

Kabbiri, R., Dora, M., Kumar, V., Elepu, G., & Gellynck, X. (2017). Mobile phone adoption in agri-food sector: Are farmers in Sub-Saharan Africa connected? *Technological Forecasting and Social Change*, *131*. doi: 10.1016/j.techfore.2017.12.010

Kafel, P., & Sikora, T. (2014). The level of management maturity in the Polish food sector and

its relation to financial performance. *Total Quality Management and Business Excellence*, *25*(5–6), 650–663. doi: 10.1080/14783363.2013.876182

Kapoor, K. K., & Dwivedi, Y. K. (2020). Sustainable consumption from the consumer's perspective: Antecedents of solar innovation adoption. *Resources, Conservation and Recycling*, *152*(May 2019), 104501. doi: 10.1016/j.resconrec.2019.104501

Kastelli, I., Tsakanikas, A., & Caloghirou, Y. (2016). Technology transfer as a mechanism for dynamic transformation in the food sector. *Journal of Technology Transfer*, *43*(4), 882–900. doi: 10.1007/s10961-016-9530-3

Khan, K. S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the Royal Society of Medicine*, *96*(3), 118–121. doi: 10.1177/014107680309600304

Kimberly, J. R., & Evanisko, M. J. (1981). Organizational Innovation: the influence of individual, organizational, and contextual factors on hospital adoption of technological and administrative innovations. *Acadamey of Management Journal*, *24*(4), 689–713.

Klerkx, L., & Rose, D. (2020). Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security*, *24*(December 2019), 100347. doi: 10.1016/j.gfs.2019.100347

Le Mouël, C., & Forslund, A. (2017). How can we feed the world in 2050? A review of the responses from global scenario studies. *European Review of Agricultural Economics*, *44*(4), 541–591. doi: 10.1093/erae/jbx006

Lee, K. H., Hwang, K. H., Kim, M., & Cho, M. (2021). 3D printed food attributes and their roles within the value-attitude-behavior model: Moderating effects of food neophobia and food technology neophobia. *Journal of Hospitality and Tourism Management*, *48*(June), 46–54. doi: 10.1016/j.jhtm.2021.05.013

Littell, J. H., Corcoran, J., & Pillai, V. (2008). *Systematic Reviews and Meta-Analysis*. Oxford University Press.

Malassis, L. (1973). *Économie agro-alimentaire: economie de la consommation et de la production agro-alimentaire*. Paris : Editions Cujas.

Massa, S., & Testa, S. (2009). A knowledge management approach to organizational competitive advantage: Evidence from the food sector. *European Management Journal*, *27*(2), 129–141. doi: 10.1016/j.emj.2008.06.005

Massa, S., & Testa, S. (2017). Opening up innovation processes through contests in the food sector. *Business Process Management Journal*, *23*(6), 1290-1310.

Matin, A. H., Goddard, E., Vandermoere, F., Blanchemanche, S., Bieberstein, A., Marette, S., & Roosen, J. (2012). Do environmental attitudes and food technology neophobia affect perceptions of the benefits of nanotechnology? *International Journal of Consumer Studies*, *36*(2), 149–157. doi: 10.1111/j.1470-6431.2011.01090.x

McAdam, M., McAdam, R., Dunn, A., & McCall, C. (2014). Development of small and medium-sized enterprise horizontal innovation networks: UK agri-food sector study. *International Small Business Journal*, *32*(7), 830–853. doi: 10.1177/0266242613476079

Mitsuda, H. (1999). Toward solutions for food crisis in the 21st century: From basic research to development of innovative food technologies. *Proceedings of the Japan Academy*, *75*(8), 246–253. doi: 10.2183/pjab.75.246

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred Reporting Items for

Systematic Reviews and Meta-Analyses: The PRISMA Statement. *Annals of Internal Medicine*, *151*(4), 264–269.

Montes de Oca Munguia, O., Pannell, D. J., & Llewellyn, R. (2021). Understanding the Adoption of Innovations in Agriculture: A review of selected conceptual models. *Agronomy*, *11*(1), 1–20. doi: 10.3390/agronomy11010139

Morgan, K., & Sonnino, R. (2010). The urban foodscape: World cities and the new food equation. *Cambridge Journal of Regions, Economy and Society*, *3*(2), 209–224. doi: 10.1093/cjres/rsq007

O'Connor, C., & Kelly, S. (2017). Facilitating knowledge management through filtered big data: SME competitiveness in an agri-food sector. *Journal of Knowledge Management*, *21*(1), 1–18.

OECD/FAO. (2017). *OECD-FAO Agricultural Outlook 2017-2026 (OECD-FAO Agricultural Outlook)*. OECD Publishing. doi: 10.1787/agr_outlook-2017-en

Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, *13*(6), 343–373.

Reisman, E. (2021). Sanitizing agri-food tech: COVID-19 and the politics of expectation. *The Journal of Peasant Studies*, *48*(5), 910–933. doi: 10.1080/03066150.2021.1934674

Rogers, E. M. (2003). *Diffusion of innovations*. 5th ed. The Free Press.

Rowe, F. (2014). What literature review is not: Diversity, boundaries and recommendations. *European Journal of Information Systems*, *23*(3), 241–255. doi: 10.1057/ejis.2014.7

Schryen, G. (2013). Revisiting IS business value research: What we already know, what we still need to know, and how we can get there. *European Journal of Information Systems*, *22*(2), 139–169. doi: 10.1057/ejis.2012.45

Schumpeter, J. A. (1985). *Teoria do desenvolvimento econômico: uma investigação sobre lucros, capital, crédito, juro e o ciclo econômico*. Editora Nova Cultural.

Schwarz, A., Mehta, M., Johnson, N., & Chin, W. W. (2007). Understanding Frameworks and Reviews: A Commentary to Assist us in Moving Our Field Forward by Analyzing Our Past. *Data Base for Advances in Information Systems*, *38*(3), 29–50. doi: 10.1145/1278253.1278259

Silveira Junior, L. A. B. (2018). *Adoção de inovações na indústria automotiva: modelo conceitual e aplicação para sistemas semiativos de amortecimento*. (Tese de Doutorado). Faculdade de Economia, Administração e Contabilidade. Programa de Pós-Graduação em Administração. Universidade de São Paulo, São paulo. Retrieved from: https://www.teses.usp.br/teses/disponiveis/12/12139/tde-17012019-160828/pt-br.php

Sonnino, R., & Griggs-Trevarthen, C. (2013). A resilient social economy? Insights from the community food sector in the UK. *Entrepreneurship and Regional Development*, *25*(3–

Stål, H. I., Bonnedahl, K. J., & Eriksson, J. (2013). The challenge of introducing low-carbon industrial practices: Institutional entrepreneurship in the agri-food sector. *European Management Journal*, *32*(2), 203–215. doi: 10.1016/j.emj.2013.06.005

Strom, S. (2016). Tyson Foods, a meat leader, invests in protein alternatives. *The New York Times*. Retrieved from: https://www.nytimes.com/2016/10/11/business/tyson-foods-a-meat-leader-invests-in-protein-alternatives.html?_r=0

Swartz, E. W. (2021). Anticipatory life cycle assessment and techno-economic assessment of

commercial cultivated meat production: a summary of recommended stakeholder actions. In *Good Food Institute*. Retrieved from: https://gfi.org/wp-content/uploads/2021/03/cultured-meat-LCA-TEA-technical.pdf

Tilman, D., & Clark, M. (2014). Global diets link environmental sustainability and human health. *Nature*, *515*(7528), 518–522. doi: 10.1038/nature13959

Timpanaro, G., Pecorino, B., Chinnici, G., Bellia, C., Cammarata, M., Cascone, G., & Scuderi, A. (2023). Exploring Innovation Adoption Behavior for Sustainable Development of Mediterranean Tree Crops. *Frontiers in Sustainable Food Systems*, *7*. doi: 10.3389/fsufs.2023.1092942

Trott, P., & Simms, C. (2017). An examination of product innovation in low- and medium-technology industries: Cases from the UK packaged food sector. *Research Policy*, *46*(3), 605–623. doi: 10.1016/j.respol.2017.01.007

Ullah, S., Khan, F. U., & Ahmad, N. (2022). Promoting sustainability through green innovation adoption: a case of manufacturing industry. *Environmental Science and Pollution Research*, *29*(14), 21119–21139. doi: 10.1007/s11356-021-17322-8

Van Dooren, C., & Brink, L. (2017, May). Eating more sustainably. *Fact sheet*. Retrieved from: https://mobiel.voedingscentrum.nl/Assets/Uploads/voedingscentrum/Documents/Professionals/Pers/Factsheets/English/Fact sheet_Eating more sustainably_2017.pdf

Viero, V. C., & Souza, R. S. (2008). Comunicação rural on line: promessa de um mundo sem fronteiras. Paper presented at the *XLVI Congresso Da Sociedade Brasileira de Economia, Administração e Sociologia Rural*. (pp. 1-15). Rio Branco, Acre. Retrieved from: https://ageconsearch.umn.edu/record/109704/files/672.pdf

Wasiq, M., Kamal, M., & Ali, N. (2023). Factors influencing green innovation adoption and its impact on the sustainability performance of small and medium sized enterprises in Saudi Arabia. *Sustainability*, *15*(3). doi: 10.3390/su15032447

Wickramasinghe, K., Breda, J., Berdzuli, N., Rippin, H., Farrand, C., & Halloran, A. (2021). The shift to plant-based diets: are we missing the point? *Global Food Security*, *29*(February), 2019–2022. doi: 10.1016/j.gfs.2021.100530