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Review

Open Innovation in the Agri-Food Sector: Perspectives from a Systematic Literature Review and a Structured Survey in MSMEs

Juan Guillermo Solarte-Montufar [1,*], Jhon Wilder Zartha-Sossa [2,*] and Oswaldo Osorio-Mora [3,*]

[1] Master's Program in Agribusiness Innovation, Faculty of Agro-Industrial Engineering, Pontifical Bolivarian University, Medellín 050031, Colombia
[2] Engineering Department, Faculty of Agroindustrial Engineering, Pontifical Bolivarian University, Medellín 050031, Colombia
[3] Department of Industrial Processes, University of Nariño, Pasto 520002, Colombia
* Correspondence: jgsolarte77@hotmail.com (J.G.S.-M.); jhon.zartha@upb.edu.co (J.W.Z.-S.); osorio_oswaldo@udenar.edu.co (O.O.-M.)

Abstract: Open innovation, understood as a strategy for business competitiveness, has experienced growing relevance, even in traditional economic sectors, such as agri-food. This article focuses on the trends and challenges of open innovation applied to the agri-food field, based on two approaches, a Systematic Literature Review (SLR) and a structured survey, answered mainly by micro-, small-, and medium-sized enterprises (MSMEs). For the SLR, the Scopus bibliographic database was chosen. Documents were filtered by type, novelty, and impact factor of the journal (based on the Scimago Rank). The final selection included 50 articles that were deeply analyzed. In addition, the survey was applied to 57 agri-food companies from the department of Nariño (Colombia), establishing a diagnosis of the extent of openness of their collaborative barriers and innovation capacities. The review's results revealed a marked European dominance in this research field. Product co-creation, eco-innovation, and bioeconomy are main fields of interest and application of open innovation. The challenges identified are related to intellectual property rights and effective communication between stakeholders. The survey was successful in establishing a statistically significant correlation between innovation performance and collaboration with external partners. As a conclusion, an open innovation approach can provide dynamism and cohesion in agri-food systems.

Keywords: open innovation; food industry; systematic literature review; structured survey; perspectives and trends

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1. Introduction

Innovation is more frequently perceived as a main determinant of businesses success, effective performance, and organization survival, regardless of their size and influence sector [1,2]. Therefore, administration management researchers and professionals are interested in understanding the underlying drivers of innovation and their effect on business performance [3]. In recent decades, collaboration between diverse external actors has been recognized as an essential element for the generation of new ideas. Likewise, the relevance of the knowledge networks, information flows, importance of learning, and social interaction for innovation have been highlighted [4].

The concept of open innovation was born within this context and was first formulated by the North American professor, Henry Chesbrough, who defined it as "the use of internal and external flows of knowledge to accelerate internal innovation and expand markets for external use of that innovation" [5,6]. Thus, the cornerstone of open innovation is the use of external knowledge by a company in order to accelerate its own internal innovation process [7].

Regarding the agri-food sector, some authors agree that diverse innovation initiatives have been developed with increasing frequency, involving various actors, such as clients,

suppliers, and universities, even though this is considered a segment with low technological developments [7–11]. On the other hand, some authors [12,13] point out that current characteristics of the agri-food sector have made collaborative processes to innovate a necessity. Companies operate in a business environment characterized by increasing competition due to globalization, reduction of trade barriers, and the consolidation of food retailers.

Innovation in the food chain involves the producers of agricultural inputs (such as fertilizers and seeds), growers of agricultural products (such as fruits and vegetables), processors that generate final agri-food products, and the distributors of these products, all of whom play a unique role in the impact of that innovation [14]. Similarly, some reports indicate that the capacity of taking advantage of knowledge based on information technology enables open innovation strategies in the agri-food field [15]. As this is a sector of recent application for open innovation, many of the research works are based on an empirical basis. Therefore, it is necessary to develop systematic literature reviews periodically, which should apply proper methodologies to gather, organize, and update information that has been recently published, contrasting empirical works and case studies of subsectors or regions to find common patterns and teachings that can be applied in a general way to agribusiness.

Within this context, this paper aims at identifying, evaluating, and interpreting, in recent reports, relevant data on open innovation, as well as trends and challenges derived from its use in the agri-food field. Furthermore, seeking to make an additional contribution to this field of study, these papers were contrasted with the innovation situation of the agri-food sector in Nariño, a region in southern Colombia. In this way, the structure of this study is divided into two parts, a Systematic Literature Review and a structured survey answered by 57 companies (mostly MSMEs), which together seek to answer the following research questions:

- RQ1: Which countries and regions lead scientific research in relation to innovation in the agri-food field?
- RQ2: Which authors and journals have the highest number of publications focused on applications of open innovation in agri-food systems?
- RQ3: What are the main topics of interest and application for open innovation within the agri-food sector?
- RQ4: What are the main challenges (detected problems and potential opportunities) that open innovation faces within the agri-food sector?
- RQ5: Regarding the application of open innovation, is the case of the agri-food sector in Nariño consistent with the findings of the SLR?
- RQ6: Is there a positive correlation between open innovation practices and the innovation performance of companies in the agri-food sector?

The results of the present work identified main characteristics and recent trends in studies that were carried out within the sector, as well as the more promising study focuses on open innovation within agri-food systems. Many countries and regions are increasingly using technology roadmaps and open innovation in order to promote sustainable regional development and safeguard both innovation initiatives and competitiveness in global markets [16]. The structured survey left a diagnosis of the capacities of innovation and motivation to collaborate with external partners in a sample that included mainly micro-companies (with less than 10 employees) and young companies. Our results show a statistically significant and positive correlation between innovation capacities of participating companies and their cooperation with various external actors. In conclusion, open innovation benefits competitiveness, cohesion, and technological and research developments of agri-food systems.

2. Conceptual Framework

Innovation is conceived as a business development strategy aimed at the (i) generation of new products and processes, (ii) adaptation of technologies, (iii) advanced training of

workers, and (iv) implementation of changes in the organizational culture, all of which are based on the competitiveness of business and community wellbeing [17]. In a broader context, innovation is beneficial for the overall society, since it improves the productive potentiality of nations, solves existing problems, or needs and plays a central role in the economic development of countries and regions. Thus, innovation gives great relevance to research and development (R&D) activities, especially those nurtured among industrial players [18,19].

Historically, most organizational knowledge was generated internally. However, only a few companies can maintain their competitiveness and innovation nowadays by focusing exclusively on internal sources [20]. Traditional innovation management models have been struggling since the end of the 20th century, mainly due to the significant increase in the number and mobility of highly qualified workers, making it difficult for companies to control and keep their ideas and specialized knowledge [5,18].

This context gave rise to the "Open Innovation" model in 2003, which was originally introduced by Henry Chesbrough in his book: Open Innovation: The New Imperative for Creating and Profiting from Technology [21]. However, Tarde (1890) first formulated the innovation framework in his research work, published more than 200 years ago [22,23]. Unlike the traditional model of integrated vertical innovation [24], where all knowledge is internalized and controlled by the company, the open innovation paradigm is characterized by porous innovation processes and by the strong interaction between the company and its environment [25].

Open innovation assumes that companies can and must use both external and internal ideas as they seek to enhance their innovations [26]. As a result, companies recognize that not all good ideas will come from within the organization and that not all good ideas formulated within organizations can be applied to their business models [18,27]. This concept is increasingly and widely recognized in the academic field and it is being put into practice by various economic sectors, where it is seen as an R&D strategy that is in accordance with the diversification of the consumer demand, business competitiveness, and need for continuous innovation [26,28].

Some authors [29] suggest that open innovation in companies generally pursues three fundamental purposes that constitute elements of analysis from the research perspective: (i) to accelerate internal innovation processes, (ii) to increase opportunities in the market, and (iii) to contribute to companies in the generation of profit. The implementation of this model provides attractive benefits to companies, including shorter releasing time for new products, lower innovation costs, better adaptation to consumer needs of products and services, and shared risk in the development of products and services [2].

Moreover, diverse authors indicate that open innovation in companies usually includes three different dynamics: (i) the inside-out process, which searches for knowledge and technologies abroad to apply them internally; (ii) the outside-in process, which involves the outsourcing and commercialization of internal innovations; and (iii) the coupled or mixed process. These three processes must transcend corporate borders and foster spaces for close collaboration with external actors to introduce mutually beneficial ideas and projects, finding a balance between outside-in and inside-out capacities for the generation of growth opportunities and business value [30–33].

On a previous review [34], which included 291 reports on open innovation and addressed elements of an outside-in model (external sources of innovation), the authors indicate that there is a trend to ignore the importance of business models of each company, despite their central role in the distinction between open innovation and simple inter-collaboration between organizations to innovate. In this respect, open innovation models not only depend on internal factors of the company (such as its R&D capacity or the available technological stock), but there are also other intrinsic factors specifically related to the industry in which each company operates [35].

The authors [28] explain that changes in the National Innovation System (NIS) of the United States catalyzed the emergence of open innovation, mentioning that several

developed nations, including OECD member states, have focused on the open innovation strategy to strengthen and improve their scientific and technological innovation capacities. Finally, in recent years, the concept of open innovation has started to be updated to "Open Innovation 2.0", which eliminates the boundaries between university, industry, government, and community, taking advantage of disruptive technologies, such as cloud computing, the internet of the things, and big data, in order to solve societal challenges in a sustainable and profitable way and with greater speed and proficiency than before [36]. Hence, this new concept connects the open innovation principles with evident social and environmental components, based on sustainability.

Innovation in the agri-food industry depends on multiple actors that interact with each other under specific rules to create new ways of approaching social and economic processes [37]. Thus, the chain of agri-food value describes an articulated set of activities, technologies, resources, and organizations that contribute to the creation, transformation, distribution, and commercialization of a specific product. Therefore, the particular attributes of this sector are key for the application of open innovation strategies [7,8]. In this context, ref. [1] argues that agri-food companies should consider the opportunities that emerge from the adoption of an open innovation approach, which include shorter trade time periods, lower R&D costs, and a better understanding of customer needs. They add that, due to its novelty, there are still many problems inherent to the application of this approach, which must be better addressed to fully integrate this new paradigm into the innovation management process of companies.

3. Materials and Methods

This article is structured in two main parts. First, a Systematic Literature Review (SLR), which aimed to identify the most relevant recent studies on the practical application of the concept of open innovation within the agri-food field. Second, the review was complemented and contrasted with a structured survey applied to a sample of 57 agri-food companies from the department of Nariño (Colombia), which sought to establish a diagnosis of their capacities of innovation and motivation to collaborate with external partners. Figure 1 summarizes the followed methodology.

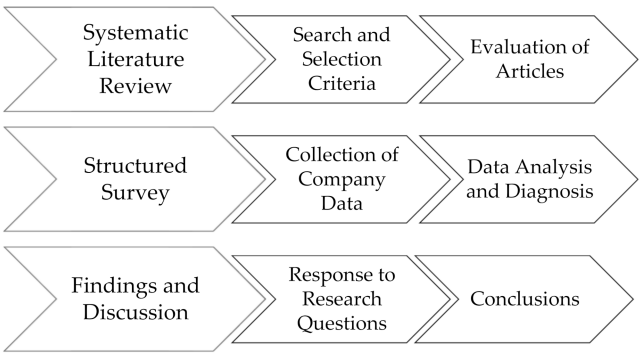


Figure 1. Outline of the study methodology.

The SLR approach originally emerged from the concept of evidence-based medicine (EBM) in the early 1960s, with the aim of improving the decision-making process by reducing the variability of practice or experience [38,39]. The protocol was used to collect, organize, evaluate, and synthesize all the available evidence regarding a phenomenon of interest within a defined period of time [35,38].

The SLR methodology was based on the high standing journals' papers of [35,38], which present reviews focused on co-creation and circular economy, respectively. In turn, the first of these reviews was based, in general terms, on the guidelines established by [40], focused on the conducting of SRL in software engineering, and, in specific terms, on the contributions by [41–43]. For its part, the review from [38] was based on [39], a guide that presents the fundamental elements to take into account SLR focused on administration and

management issues. First, the Scopus bibliographic database was selected as the search engine, a decision based on its international importance and complete multidisciplinary coverage. Subsequently, two search equations were used in the search engine with different approaches to open innovation applications. While the first equation was focused on reports within the primary production sector, the second was centered on studies about the food industry:

Equation (1):

$$\text{TITLE-ABS-KEY (“open innovation” AND agri* OR agro*)} \quad (1)$$

Equation (2):

$$\text{TITLE}-\text{ABS}-\text{KEY (“open innovation” AND food AND NOT agr*)} \quad (2)$$

The asterisk at the end of a term means that the search equation will address all the words that begin with the letters that precede this symbol. The (1) and (2) search equations produced 64 and 107 documents, respectively (a total of 171 reports). Thus, the following selection filters and criteria were established to prioritize the quality of the information:

- Document type: the search was limited only to scientific articles, excluding other bibliographic sources, such as books, book chapters, dissertations, press articles, and repositories of conferences and congresses.
- Novelty of the information: papers published between February 2013 and February 2020 were selected only. This was considered an adequate period to identify current methodologies and significant advances in the field of study, since open innovation processes are closely linked to information and communication technologies (used to connect stakeholders), and therefore, such processes are not unrelated to its accelerated changes.
- Impact and relevance degree: the SCImago SJR (Journal & Country Rank) index and its impact measurement quartiles were used as a reference. Only articles published by journals within the Q1 and Q2 quartiles were chosen.
- Additionally, it was verified that the remaining articles were directly related to the academic field of this research work.

The application of these filters for time, impact, and document time reduced the total number of reports to review from 171 to 50.

After this final selection, the articles were read and evaluated in depth. A research log was then created to efficiently manage the found information. This log was used to classify the articles according to their year of publication, authors, country(s) of affiliation, journal of publication, journal impact factor (SJR), Scimago quartile, and keywords. Likewise, relevant factors for the analysis of the set of documents were included, such as the use of open innovation models and/or platforms, the specific subsector of study or application, the number of companies/actors involved (for case studies), the methodology used, and the problems that were identified. The information loaded into the research log was used as an input to feed the Vantage Point data mining software, which identifies patterns and trends within a set of documents that would be difficult to recognize only through a visual inspection.

On the other hand, the structured survey sample covered 57 companies from the department (state) of Nariño (located at the southern part of Colombia), which belonged to different agri-food links and chains. The questionnaire used was adapted from three previous reports [44–46], the analysis of the 50 articles selected for the systematic literature review, and an additional section related to the impact generated by the new SARS-CoV-2 coronavirus in the innovation of the companies. The questionnaire included 42 questions, divided into the following 11 sections:

1. General data of the organization: name, size (number of employees), seniority, municipality(s) of coverage, and position in the food change

2. Section on general innovation competencies of the company: 7 questions (Yes/No)
3. Section on open innovation platforms and challenges: an informative video summarizing the concept of open innovation and 5 questions (Yes/No)
4. Section on collaborations with external partners in the innovation process (customers): 4 questions, Likert scale (1–5)
5. Section on collaborations with external partners in the innovation process (suppliers): 4 questions, Likert scale (1–5)
6. Section on collaborations with external partners in the innovation process (competitors): 3 questions, Likert scale (1–5)
7. Section on collaborations with external partners in the innovation process (universities, research groups): 4 questions, Likert scale (1–5)
8. Section on collaborations with external partners in the innovation process (independent experts): 4 questions, Likert scale (1–5)
9. Section on performance assessment (innovation performance): 6 questions, Likert scale (1–5)
10. Section on performance assessment (propensity for innovation): 4 questions
11. Section on the effects of the COVID-19 pandemic on innovation: 3 questions with multiple items, Likert scale (3–3)

The complete questionnaire can be consulted in the appendix section of this document. The statistical analysis of the data was carried out through the Statgraphics 18© program.

4. Results and Data Analysis

4.1. Systematic Literature Review

Table 1 shows the document selection process for the two established search questions. Here, the initial results and those obtained after the application of the filters mentioned in the methodology are highlighted. The final number of selected and analyzed articles was 50.

Table 1. Document selection process.

Search Equation	Documents Found	Filter 1: Type and Novelty	Filter 2: Relevance and Impact	Filter 3: Topics
TITLE-ABS-KEY ("open innovation" AND agri* OR agro*)	64	54	31	29
TITLE-ABS-KEY ("open innovation" AND food AND NOT agr*)	107	36	22	21
Total	171	90	53	50

The number of publications from 2013 to February 2020 can be seen in Figure 2. The highest number of studies were registered in 2017, and there seems to be a downward trend from this point.

The information obtained from the final selection of articles and their analysis was fed into The Vantage Point data mining software to answer the research questions.

4.1.1. RQ1: Which Countries and Regions Lead Scientific Research in Relation to Innovation in the Agri-Food Field?

Table 2 shows the first 10 countries with the highest number of publications, adding results from the two equations. As seen, this rank is dominated by European countries that develop research related to open innovation in the agri-food field. Italy is the country with the highest number of publications, with 12 reports [1,7,15,47–55], followed by the Netherlands and Spain, with 7 and 5, respectively.

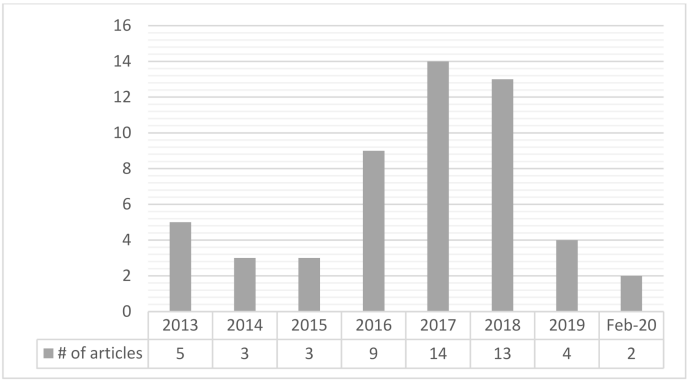


Figure 2. Dynamics of yearly publications.

Table 2. Top 10 countries with the highest number of publications.

Rank	Country	Number of Articles
1	Italy	12
2	Netherlands	7
3	Spain	5
4	Israel	4
5	UK	4
6	Germany	4
7	France	3
8	Hungary	3
9	Australia	2
10	Greece	2

Figure 3 displays academic collaborations between the top 10 countries with the highest number of publications. The graph shows that Italian authors, who published the most, do not seem to create networks with researchers from the other nations. The same situation is observed for authors from Spain and Germany.

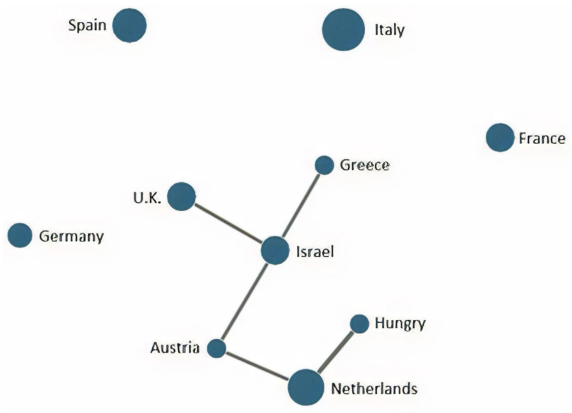


Figure 3. Matrix of academic collaborations between the top 10 countries.

Outside the European continent, Israel is a highly productive country, with four articles [56–59]. The author of all these reports is the professor Sam Saguy, in collaboration with authors from other nations. Some of his studies are focused on curricula of academic programs related to the agri-food sector, indicating that open innovation offers new possibilities and unique opportunities for universities to lead a change from the industrial and academic conservatism that has led the sector to be traditionally considered as having a low-tech intensity. The list also includes reports from Australia [59,60], Canada [61,62], India [8], and Turkey [31].

Surprisingly, the United States, a country considered an agricultural and industrial authority, has only one article from authors that collaborated with French researchers [63]. These authors studied product innovation in agri-food companies and concluded that governments could encourage open innovation through sponsored research or by sharing costs with companies.

4.1.2. RQ2: Which Authors and Journals Have the Highest Number of Publications on Applications of Open Innovation within the Agri-Food Sector?

The journals with the highest impact and number publications can be observed in Figure 4.

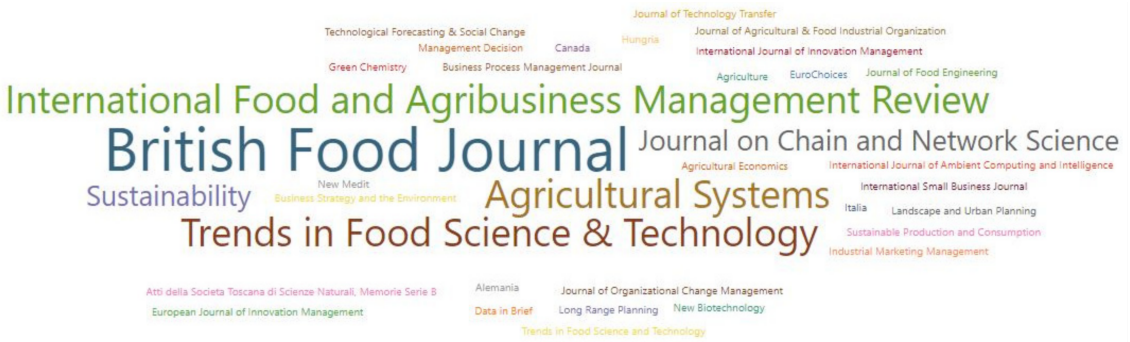


Figure 4. Journals with the highest number of publications.

From the selection, the journal with the highest number of articles is the British Food Journal with nine reports [7,14,15,48,52,53,64–66]. This is a journal with more than 120 years of history focused on research applied to the food industry. The Dutch journal Trends in Food Science and Technology is ranked second in the list, with four studies [1,57,58,61], and it is one of the most recognized international peer-reviewed journals, publishing critical reviews and commentaries on current technology, food science, and human nutrition. The American journal, the International Food and Agrobusiness Management Review, is ranked third, with three reports [63,67,68], sharing this position with the British journal, Agricultural systems (Q1) [12,13,69].

Figure 5 displays the authors with the highest number of articles and their academic collaborations. Five work clusters stand out, most with two collaborations. The Israeli author, Sam Saguy, has the highest number of papers, followed by the Hungarian Professor József Tóth, with three published studies [14,68,70] focused on the absorption capacities of open innovation processes by food companies.

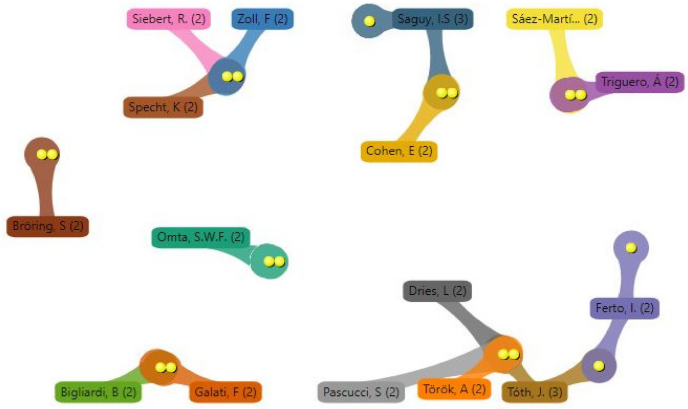


Figure 5. Collaboration clusters among the top 16 main authors.

Authors with more than one article, who were not part of any of the previous clusters, were also identified in the selection. For instance, the Dutch author, S.W.F. Omta,

addresses highly relevant topics, such as intellectual property, cooperative companies, and open innovation platforms [71,72]. Additionally, S. Bröring, a German researcher, studies bioeconomy and barriers to the adoption of open innovation technologies [61,73].

4.1.3. RQ3: What Are the Main Topics of Interest and Application for Open Innovation within the Agri-Food Sector?

A complete assessment of the content of the selected studies was carried out to answer this question, and this information was cross referenced with the set of the most frequent keywords used by the authors included in this review. The data was used to create a cluster diagram from the top 8 keywords (Figure 6).

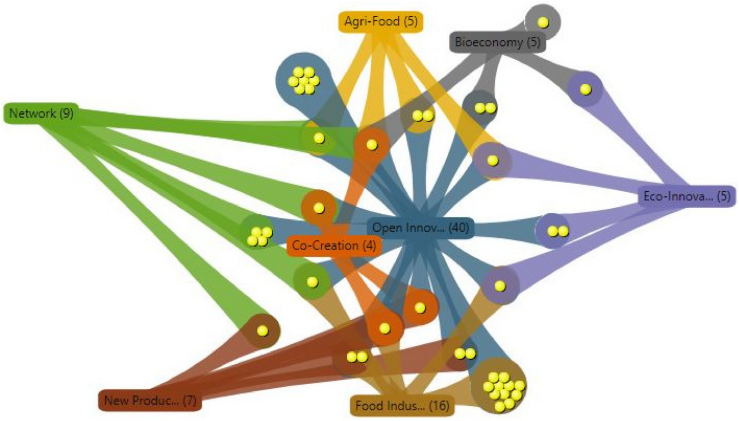


Figure 6. Cluster of relationships between the top 8 keywords.

With seven citations between keywords of the set of documents [30,48,52,64,66,68,72], the development of new products is one of the most recurrent applications for the open innovation approach, especially within the food industry. Eco-innovation is another sub-sector study of growing interest in relation to open innovation [32,33,74]. Finally, bioeconomy stands out within the dataset, especially with studies related to the agricultural sector [69,73,75].

A summary of the most relevant information found regarding these study topics and their relationship with the open innovation approach within the agri-food sector is presented below:

- Development of New Products:

Some studies [76,77] highlight the importance of customers/consumers as key actors in the co-creation of new products, together in association with transformer companies and supported by computerized communication tools. They also show how these processes allow companies to better adapt to market trends. Likewise, the authors emphasize the importance of proper communication and commitment of the parties in this type of association. Other researchers [52] indicate that most empirical studies within the open innovation field include heterogeneous samples of companies from different industrial sectors, despite the fact that innovation is frequently affected by particularities of each specific sector. In this respect, they state that there is a lack of empirical evidence from food and beverage companies involved in open innovation processes.

Those authors [52] also indicate that some companies are reluctant to open up due to traditional values, even though an innovation approach is necessary to remain competitive. Their results show that companies benefit from adopting models to gather external knowledge. Particularly, market-based sources (e.g., customers and provider relationships) are beneficial for incremental innovation and marketing time periods, whereas science-based sources (relationships with academia members and independent experts) are more beneficial for radical innovation. They conclude that the intensity of internal R&D amplifies the benefits.

Research conducted by [30] shows a direct relation between innovation level, external openness, and open innovation management with intellectual property. They suggest that implementing open strategies that involve clients improves overall performance, but they indicate that results depend on the implementation of proper communication channels and a structured model to manage. They conclude that open innovation requires a management model to capture useful and valuable knowledge and, consequently, to assess, in the short and medium term whether organizational changes are worth it.

In their work on how different forms of openness shape the development of new products in the Norwegian cereal industry, [64] conclude that clarity in the interaction with machinery suppliers is key to reaching successful innovations and state that, in practice, companies are more open than they think. Factors such as mutual trust, control, and distribution of assets are positive for openness in innovation processes carried out with suppliers.

Finally, various authors think that open innovation represents an especially attractive opportunity for agri-food SMEs, since they can benefit from the lower economic investment that comes from applying external knowledge and technologies, presiding over or reducing dependence from internal R&D and accelerating the development and release of new products that are more in line with market needs [1,14,49,70,78,79].

- Eco-innovations:

Reference [54] indicates that, even though the reference literature has increased recently, empirical research in traditionally low-technology sectors, such as agri-food, continues to be scarce. Although this sector has traditionally shown little propensity to innovate products and/or processes, especially small companies, the authors argue that many companies have chosen to implement eco-innovations in recent years. References [9,32] attribute this trend to the exploitation of technological changes external to the sector and to a greater environmental awareness of consumers. In addition, they highlight that new technological discoveries in fields such as biotechnology, nutrition, ICT, and health care have facilitated the adoption of eco-innovations in the industry.

In their research, ref. [32] explore the relationship between inbound open knowledge and technology strategies and performance of eco-innovative companies belonging to the food and beverage industry. The authors divided eco-innovative companies into three groups based on their growth and success in the food industry of Spain. As a result, they found that the diversity of collaborators (a wide range of external sources of knowledge) and the joint adoption of eco-innovations in products and processes are positively associated with the probability of achieving a high sales growth. In addition, they highlight that operational flexibility, knowledge-based capacities, and company size are also positively related to the success of eco-innovative companies.

Reference [33] analyzed the influence of open innovation strategies on eco-innovation, assessing the type of innovation (product vs. process) and the degree of novelty (radical vs. incremental). Their study confirms the influence of both market demands and regulatory factors on the general adoption of eco-innovations. Likewise, they showed that the depth of external sources of knowledge is only significant for incremental processes, products, and eco-innovations related to a more efficient use of materials and energy, but not for radical innovations. Finally, the authors [74] highlight the importance of trust in relationships with the involved parties in order to create an atmosphere that encourages the fluid exchange of knowledge between partners, especially when innovations in eco-processes are being developed.

- Bioeconomy:

This concept implies the opportunity and need to reconcile economic growth with an environmentally responsible action and includes all industries and economic sectors that produce, manage, or use biological resources (e.g., agriculture, the food industry, forestry, fishery) [80]. The authors [68] state that the evolution of the bioeconomy is still at a strategic level and point out the need for scientific research to develop a solid concept

and make its implementation manageable. They also argue that value chains, especially those from the agri-food, industrial, and energy sectors, will merge due to a shift to bio-based raw materials, which will generate a mutual dependence and generate new flows of materials and food processing technologies. Finally, they conclude that the creation and exchange of new knowledge between different scientific disciplines requires R&D and innovation within targeted technologies, connecting knowledge-based bioeconomy with the management of technology and innovation.

Study [69] suggests that there is an urgent need to renew the traditional organization and management of agriculture and promote more open, decentralized, contextualized, and participatory approaches for the design and innovation of the sector. They highlight that innovation ecosystems, collective design management, participatory design management, the analysis of systems, and network leadership have become new tools to support sustainable agriculture and foster broader transitions towards the diversity of food systems and circular bioeconomy.

4.1.4. RQ4: What Are the Main Challenges (Detected Problems and Potential Opportunities) That Open Innovation Faces within the Agri-Food Sector?

In terms of challenges of open innovation, several studies [62,72,75] indicate that there are recurrent associativity issues, such as the lack of financial support for technology transfer, diffuse legal frameworks regarding intellectual property of innovations, and communication barriers between parties. These factors affect the progress of open innovation projects and translate into greater spending of time and/or money or even into the failure of the initiatives. In this sense, and from their study on open innovation in urban agricultural systems in Berlin, ref. [81] conclude that correctly establishing the objectives of the projects at the beginning of the associations prevents problems in future phases and uncertainties about expected results.

Another frequent problem observed in some of the reviewed papers [54,62,72] is the handling of intellectual property rights of innovations jointly developed by companies and collaborators in open innovation models. Companies often disregard protecting their organizational knowledge when they engage in these types of collaborations. This situation can increase the vulnerability of the organization to different risks related to open innovation [82], putting the company's competitive advantage at risk, which has a negative impact on its long-term sustainability. In general, a simple way to share intellectual property in the food industry sector would be as follows: the competency provider partner should provide all physical solutions (e.g., ingredients and technology), whereas the receiving party (e.g., the food company) should be in charge of the logical applications for these solutions [1].

The management of intellectual property by companies ranges from confidentiality agreements to patents. Another strategic scheme to reduce risks could be to restrict external sources available to companies so they can focus on the most valuable sources according to the knowledge they need to access, also providing the necessary means to acquire and absorb that knowledge [12].

4.2. Results of Surveys to Agri-Food Companies from Nariño, Colombia

This section seeks to answer the last two research questions, based on the results of the applied questionnaire.

4.2.1. RQ5: Regarding the Application of Open Innovation, Is the Case of the Agri-Food Sector in Nariño Consistent with the Findings of the SLR?

- Characteristics of sample and general innovation capabilities:

Table 3 summarizes the composition of the sample of companies according to their size, years in business, and position in the chain in which they operate. Most companies can be considered SMEs, since only one of the companies surveyed has a plant of employees greater than 250. Furthermore, more than 90% of the companies in the sample

can be considered small or micro companies. In addition, young companies (1–3 years of operation) represent 40.4% of the sample.

Table 3. Role, size, and years of operation of surveyed companies.

Role in the Food Chain	Number of Companies	Percentage (%)
Primary Production	17	29.8
Processing/Transformation	38	66.7
Food Trade/Sales	17	29.8
Size of the Company	**Number of Companies**	**Percentage (%)**
<10 employees	44	77.2
11–50 employees	8	14
51–100 employees	3	5.3
100–250 employees	1	1.8
>250 employees	1	1.8
Years of Operation	**Number of Companies**	**Percentage (%)**
1–3 years	23	40.4
3–7 years	11	19.3
7–12 years	11	19.3
12–20 years	5	8.8
>20 years	7	12.3

On the other hand, Table 4 shows the classification of the surveyed companies according to their main activity. The most common economic subsectors in the companies in the sample were coffee (17.5%), including production, processing, and/or sale of raw coffee or coffee made by their own brand and fruits and vegetables (15.8%); this includes companies dedicated to processing crops such as potatoes, strawberries, and tropical fruits for export.

Table 4. Classification of companies according to their economic activity.

Main Activity/Sector	Number of Companies	Percentage (%)
Coffee and Derivatives	10	17.5%
Other Processed Foods	9	15.8%
Fruit and Vegetable Processing	9	15.8%
Dairy Products	8	14.0%
Chocolate and Confectionery	7	12.3%
Meat Products	4	7.0%
Wholesale Food Trade	3	5.3%
Fried Snacks (Chips)	3	5.3%
Aquaculture	2	3.5%
Frozen or Refrigerated Foods	2	3.5%
Total	57	100%

Dairy companies and chocolate and confectionery companies (mainly artisan products from the region made from sugar cane) also stand out in the sample, with 14% and 12.3%, respectively. For its part, the "other processed foods" classification includes companies that make ice creams, ready mixes for milkshakes, or regional products, such as panela (a product derived from sugar cane used to make beverages) and precooked arepas (snacks made from wheat or corn flour).

The economic activities of the surveyed companies are consistent with the agricultural production of the region, since potatoes, cocoa, coffee, and dairy cattle stand out as the main economic activities of the rural sector of the department of Nariño [83].

The questions included in the survey are presented in Table 5, together with the coding system that is used in Figure 7, which shows a summary and outline of the set of answers of the section about innovation capabilities of companies.

Table 5. Questions about general innovation competencies.

Question	Code
Does your company's strategy take innovation into account and is it considered a key factor for your success?	Key Factor
Does your company have a Research and Development unit? (R&D)?	R&D Unit
Has your company formulated or implemented an innovation strategy? (a formal plan containing objective, actions to carry out, resources, and budget necessary for the development of innovation activities)	Innov. Strat.
Has your company executed technological surveillance studies?	Tech. Surv.
Has your company developed or participated in open innovation processes?	Open Innov.
Does your company have: An Innovation Model, an Innovation Management Model, or an Innovation Management System?	Innov. Mgmt.

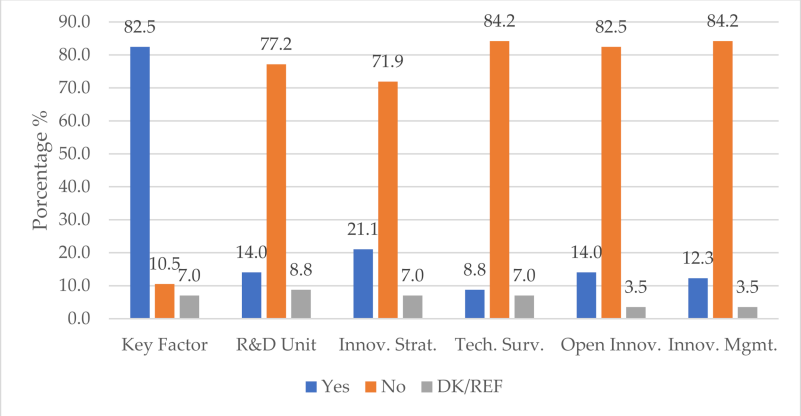


Figure 7. Results of the companies surveyed in relation to their innovation general competencies.

As shown in Figure 7, most of the surveyed companies consider innovation as a key factor for their success (47 companies: 82.5%). However, this item diverges from the rest of the results. In contrast to the first question, only 14% of the companies have an I + D unit, 21.1% have implemented or formulated an innovation strategy, and only 12.3% have an innovation management system or model. Considering the composition of the sample, it is possible that, although many companies understand the importance of innovation in their business models, they do not have the experience or the resources to manage their innovation in a systematic way.

Reference [46] assessed the innovation capabilities of 460 companies from the department of Quindío, Colombia, and reported similar contradictions between the importance that factories say they give to innovation and the investments and strategies that they actually implement in this regard. It should be highlighted that the economy of the department of Nariño depends on the agricultural sector to a great extent. However, this sector paradoxically shows numerous historical barriers, such as scarce technological innovation and lack of horizontal and vertical associativity between the members of the different food chains, which have limited its development and growth [84,85].

The widespread limited innovation capabilities observed in the agri-food sector of Nariño are evident in the analysis of the composition of the surveyed sample of companies, which is made up mostly of young micro-companies. These organizations most likely do not have the financial or technical resources to create a research and development unit or prepare a technology surveillance study. This problem is evident in the answers to the last question of this section about the investments made in research and development. More than half of the surveyed companies do not allocate financial resources for R&D activities, and none of them invest more than 5% of their income on such tasks.

The next section of the questionnaire dealt with open innovation platforms. The results showed that 86% of the studied companies had no knowledge of the concept of open innovation before answering the questionnaire. However, it is interesting that 89.3% of the companies consider that this approach and its application through open innovation

platforms and challenges could be useful for their business models. Even more relevant is the fact that 71.4% of those surveyed companies said that they were willing to implement this type of initiative.

The companies were also surveyed whether they think that the organization would benefit from an outside-in (where knowledge and technologies are searched outside to be applied in the company), inside-out (exporting or commercializing their own internal knowledge, this way helping other companies to solve their problems), or a mixed (a combination of the two previous initiatives) model. Figure 8 illustrates the results.

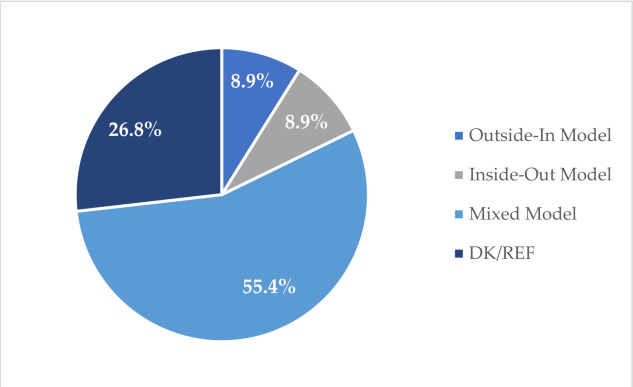


Figure 8. Most likely adoption open innovation approaches among surveyed companies.

As can be seen in Figure 8, most surveyed companies (55.4%) indicate that the most appropriate approach model for their business would be the mixed approach. Furthermore, 8.9% of companies indicated that they believe they could benefit from an inside-out approach. Considering the data presented in Figure 7, it is striking that a large percentage of those surveyed consider that their companies could be good candidates for a mixed or inside-out approach, since most companies have poor innovation capabilities.

Open innovation from the inside-out requires that companies present a solid innovation management structure and the broad integration of multiple technologies that are usually foreign to MSMEs. Therefore, outside in open innovation is the most widely adopted by companies and is also the most studied by academics [86].

This inconsistency can be explained by the fact that most of the surveyed companies had no prior knowledge of the concept of open innovation and its different approaches, in fact, almost 30% of the respondents did not answer this question. However, considering that the sample is mainly made up of young microenterprises and companies that, therefore, may not have the financial resources to innovate in a systematic way, they could greatly benefit from outside-in models, finding external solutions to their various problems and challenges with a lower budget.

- Collaboration with external partners in the innovation process:

Participants were asked about their companies' relationships with five external factors involved in the innovation process: suppliers, buyers, universities (research groups), competitors, and independent experts. Each of these fields were included in an independent section that, in turn, had several questions or items that were answered using the Likert scale from 1 to 5.

Cronbach's alpha coefficient was used to assess the internal validity and reliability of the scales that included several items. The statistical summary of these variables can be found in Table 6, which also shows values of performance and propensity towards innovation of the companies. Here, the same type of scale was used.

Table 6. Statistical summary of validity of variables assessed through a Likert scale.

Variable	Questions	Cronbach's α	Sample Average	Standard Deviation SD
Cooperation with customers	4	0.74	2.82	1.00
Cooperation with suppliers	4	0.89	3.06	1.21
Cooperation with competitors	3	0.85	2.03	1.12
Cooperation with universities	4	0.92	2.03	1.18
Cooperation with independent experts	4	0.87	2.57	1.24
Innovation Performance	6	0.91	2.64	1.16
Innovation Propensity	4	0.92	3.58	1.26

The closer Cronbach's alpha is to 1, the more consistent the items will be with each other. The values of this coefficient for the analyzed variables ranged between 0.74 and 0.92. According to [87], Cronbach's values higher than 0.7 are considered acceptable, while those higher than 0.8 are desirable. Similarly, [44] considered Cronbach's alpha values between 0.60 and 0.92 as acceptable for their study. In the Supplementary Materials section, there is a link to the average response values of all the questions that make up the parameters.

The extent of collaboration of the surveyed companies with all the external actors analyzed is deficient, since average values between 2–3 were obtained in all cases (the scale used ranges from 1 to 5). From this data set, the variable with the highest score was cooperation with suppliers.

On the other hand, the weakest relationships of companies correspond to those established with universities and competitors. The relationship with competitors was similarly the worst rated variable [44], working on a diverse sample of companies in Austria. Indeed, their methodological basis was followed in this section, which considered four additional types of external actors (intermediaries, communities, non-governmental organizations (NGOs), and public institutions). Considering the distrust and uncertainty involved in working hand in hand with direct competitors, this result is understandable. On the contrary, the researchers indicate that collaborations with universities was one of the best valued (3.62 in average), placed only below relationships with customers.

In their research on the degree of openness of small- and medium-sized agro-industrial business in the department of Atlántico, Colombia, [88] indicate that acquisition capacity, geographical proximity to customers and suppliers, signing of contracts, size, and innovation barriers are the significant variables that explain the breadth and depth in the use of external sources to innovate and reveal the need to create environments that encourage the creation of cooperative interorganizational networks to innovate in order to consolidate geographic spaces based on the economy of knowledge. On the other hand, [89] studied the barriers to the use of the open adoption by small- and medium-sized companies in Ghana and stated that the main drawbacks are related to the difficulty in finding suitable partners, cooperation, and coordination problems related to operational functions, lack of flexible internal structures, organizational inertia, and opportunistic or individualistic behavior of the partners.

The average scores for the variables Innovation Performance (6 questions) and Innovation Propensity (4 questions) were 2.64 out of 5 and 3.58 out of 5, respectively.

Thus, answering RQ5, the department of Nariño has specific conditions that were reflected in the composition of the sample of companies that answered the questionnaire. It is a region with a strong agricultural vocation, which is generally expressed in smallholdings. However, despite being generated from quality raw materials, the department's processing industry never developed strongly [84,85,90]. Therefore, there are not many large food companies in the region, which was reflected in the survey. In fact, most of the companies surveyed belong to the so-called micro-companies (less than 10 employees).

This gives the sample different characteristics from most cases studied in the SLR, such as the work of [44] (one of the references in the elaboration of the questionnaire), carried out in Austria and in whose sample almost 92% of the companies had more than 100 employees. This may explain the marked differences between the results of this work

and the study, for example, the mean values for the innovation performance of companies of 2.64 and 3.79, respectively.

The general innovation capabilities of companies are also quite deficient (Figure 7), and the budget for innovation is minimal. However, the responses also reveal that some companies are concerned about maintaining good relations with some of their external partners (mainly with suppliers) and seem to participate in joint innovation processes, despite being unaware of the theoretical concept of open innovation.

In accordance with this, [14] suggest that collaboration processes with suppliers are common in the agri-food industry because incremental innovations tend to emerge from intense relationships established between buyers, suppliers, and other business partners. They point out that small- and medium-sized companies develop this type of alliance, since they do not have sufficient financial, labor, or infrastructure capacities to carry out their own conventional type of closed innovation. A similar diagnosis was reached by [66], who studied a sample of 14 agri-food Vietnamese companies and found that they had no experience with innovation in the development of new products and were not familiar with joint creation. Nevertheless, these companies recognized the need for innovation and were enthusiastic about the co-creation approach.

4.2.2. RQ6: Is There a Positive Correlation Between Open Innovation Practices and the Innovation Performance of Companies in the Agri-Food Sector?

To answer the last research question based on the data collected by the questionnaire, a statistical analysis was performed using Pearson's correlation coefficient and benchmarking approach. Thus, a statistically significant positive correlation between the average innovation performance of the companies and their degree of collaboration with the five analyzed external actors was observed (Pearson > 0.7). This dataset can be seen in Table 7.

Table 7. Pearson's correlations between innovation performance and collaboration with various external partners.

	Innovation Performance	**Customers**	**Suppliers**	**Competitors**	**Universities**	**Ind. Experts**
Innovation Performance	Correlation (r)	0.6479	0.571	0.3736	0.5474	0.6106
	p-Value	0.0000	0.0000	0.0064	0.0000	0.0000
Customers	0.6479	Correlation (r)	0.6973	0.5141	0.503	0.6424
	0.0000	*p*-Value	0.0000	0.0001	0.0001	0.0000
Suppliers	0.571	0.6973	Correlation (r)	0.4674	0.5445	0.7076
	0.0000	0.0000	*p*-Value	0.0005	0.0000	0.0000
Competitors	0.3736	0.5141	0.4674	Correlation (r)	0.5482	0.6124
	0.0064	0.0001	0.0005	*p*-Value	0.0000	0.0000
Universities	0.5474	0.503	0.5445	0.5482	Correlation (r)	0.7007
	0.0000	0.0001	0.0000	0.0000	*p*-Value	0.0000
Independent Experts	0.6106	0.6424	0.7076	0.6124	0.7007	Correlation (r)
	0.0000	0.0000	0.0000	0.0000	0.0000	*p*-Value

Note: r = Pearson's correlation coefficient. r > 0 indicates a positive correlation. Values of $p < 0.01$ indicate that the correlation is statistically significant, with a confidence level of 99%.

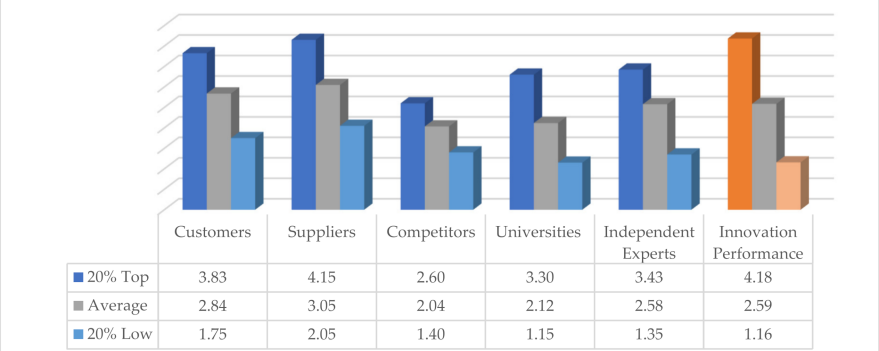
The strongest correlation of innovation performance was established with collaboration with customers (r = 0.6479. $p = 0.0000$), whereas the correlation with collaboration with competitors was the weakest (r = 0.3736. $p = 0.0064$)). The more marked correlation allows us to infer that cooperation with customers may be more profitable and fruitful for the innovation performance of companies than their relationships with competitors. However, joint innovation between competitors was scarce in most of the companies surveyed, which may be due to the trust problems present in this type of association.

In addition, reference [44] reported similar results, finding positive and significant correlations between economic performance in innovation and collaborations with three (customers, universities, and NGOs) of the nine external partners that where assessed, in which collaborations with customers (r = 0.33; $p < 0.001$) was the strongest correlation.

Traditionally, agri-food companies pursue ever closer relationships with their customers to better understand their expectations and needs. According to [67], this path often leads to co-creation, which is supported by customer engagement and uses their feedback to improve product development. This process requires the participation of customers in studies aimed at understanding the impact and performance of the product. [63] states that product innovation promotes short- and long-term growth, since it attracts customers and satisfies existing customers.

The correlations revealed in this study were complemented by applying a benchmarking approach. This is a commonly used procedure that identifies successful factors, so it is considered an appropriate method to explore what better-performing companies do differently in comparison to their less successful peers. Therefore, benchmarking is used to identify factors (e.g., open innovation management practices) that could be responsible for achieving superior results over competitors [44].

In this case, the companies that left blank answers in the questionnaire were omitted, since inconsistencies in the average values could be generated due to lack of information. Thus, the sample considered for the benchmarking approach was 52 companies. As can be seen in Figure 9, the top reference group for the analysis corresponded to companies in 20% of the upper quartile (10 companies), with respect to the average values of the composite variable Performance in Innovation.



	Customers	Suppliers	Competitors	Universities	Independent Experts	Innovation Performance
20% Top	3.83	4.15	2.60	3.30	3.43	4.18
Average	2.84	3.05	2.04	2.12	2.58	2.59
20% Low	1.75	2.05	1.40	1.15	1.35	1.16

Figure 9. Comparative study of companies with the best and worst results.

It is evident that, compared to companies with the worst performance, those with better innovation performance also establish fruitful relationships with each of the analyzed external partners, which is corroborated by the results from the Pearson's correlation analysis. The largest gap between the best and worst performing companies was observed in the collaboration with universities item ($\Delta = 2.15$), while collaboration with competitors showed the smallest gap ($\Delta = 1.20$), although the best performing companies developed better relationships with these actors.

According to [12], interactions with academia throughout the innovation process has potential benefits for the actors involved in the productive chains as they constitute a key mechanism in generating impacts, which can be observed in the diversity of products resulting from new knowledge, methods, technologies, training modules, and experimental networks. They also suggest that the way in which the interactions between researchers and other innovation actors are structured is a decisive factor in shaping the impact pathway outlined by the research endeavor.

4.2.3. Effects of Covid-19 Pandemic

In this section, and based on seven different aspects, participants were asked about the effect that the new coronavirus pandemic has had on their companies. A Likert scale, ranging from −3 to 3 (from highly negative to highly positive effects), was used, which also included a null affectation (0). The variables considered and their statistical values are summarized in Table 8. The average number of surveyed companies state that the pandemic negatively affected their business in all the previously assessed variables, with

innovation budget being the most affected. Indeed, 41 companies experienced negative effects on their innovation budget because of the pandemic and 55.4% of the sample reported a strong negative impact in this regard (a score of −3).

Table 8. Effects of the COVID-19 pandemic on the surveyed companies.

Variable	Average	SD (s)
Innovation budget	−1.87	1.63
Innovation capabilities	−1.42	1.81
Relationship with customers	−1.21	2.06
Relationship with suppliers	−0.92	1.98
Closing or opening of new markets	−1.23	2.07
Participation in innovation challenges	−1.19	1.68
General performance of the company	−1.36	1.74

Note: A Likert scale from −3 (highly negative effects) to 3 (highly positive effects) was used.

Similar results were obtained when participants were asked about the affects they foresaw in a year on their companies because of the pandemic. However, the magnitude of the expected effect was less than or equal to all the studied factors. In both cases, participants thought that their relationship with suppliers would be the least affected.

5. Discussion

Based on a Systematic Literature Review and the application of a structured survey, this article made it possible to compile the trends, benefits, and challenges that open innovation poses to the agri-food sector.

The SLR approach was used to deeply analyze 50 recent articles published in Q1 and Q2 journals. As a result, the most influential and representative countries and researchers, in terms of open innovation studies focused on the agri-food sector, were identified.

The results reveal a clear leadership of European countries regarding the number of publications in higher impact journals, with Italy, the Netherlands, and Spain in the top positions. The clear dominance of European countries, mainly Western Europe, regarding high-impact publications in this field is not surprising. The existence of traditional research centers in agribusiness, countries that are world leaders in agricultural innovation, such as the Netherlands, and technology transfer models that efficiently connect academia with companies in the sector give the old continent a vast advantage over other nations [70,75].

Studies with similar approaches, such as [6], coincide in this assessment. In their review work on open innovation in the agri-food chain, among 45 articles published between 2006 and 2015, European authors represented 90% of the selection.

A comprehensive literature review on general open innovation, which included 1046 articles published between 2003 and 2017 in 318 journals (Social Sciences Citation Index–SSCI) [22], revealed that Europe was the most productive continent, highlighting the notable increase in publications from Italy in recent years. However, this report ranked the United States in first position, with the largest number of articles published, showing that the North American nation, where the concept of open innovation first emerged, continues to be a focal point for related research; however, the agri-food sector does not seem to be a topic of greater interest in these studies.

Likewise, the main trends, application subsectors, and prominent challenges in studies that are being carried out within the sector were presented. The most promising study focuses on open innovation within the agri-food systems that correspond to development of new products: co-creation, bioeconomy, and eco-innovations.

The last two topics show that the current situation in the agri-food sector is not alien to global trends in favor of cleaner economics and green technologies. It is also evidenced that companies can be greatly benefited in this regard by working together with the other links in their production chain and, therefore, by approaches such as open innovation.

Regarding the structured survey, there was a sample of 57 companies from the department (state) of Nariño. The surveyed companies (mostly micro and young companies)

presented, on average, poor innovation capacities and reported low investments in this regard. However, most reported considering innovation as a key factor in business success and said they were interested in participating in open innovation processes.

The foregoing allows us to infer that the limited innovation capacities of the sample are more related to economic barriers than disinterest or lack of will. In this sense, the agri-food sector in the region could greatly benefit from the adoption of open innovation models that allow companies to have access to external solutions to their innovation challenges. An outside-in model of open innovation seems to be the most promising for these types of companies.

It is especially advisable to narrow the support channels between the universities and the business sector, since the associations with this type of institutes were among the weakest, according to the responses to the survey. Studies such [45] suggest that universities are one of the most solid sources of external knowledge, showing a positive correlation between active collaboration with universities and technological innovation of the company, in addition to relationships with the future direction of the company's market and the development of new products. Other research [9] reveals the role of academia in the processes of technological scaling of relationships with the competitiveness of various industries.

Furthermore, a section that was useful for determining the impact experienced by companies because of the new coronavirus SARS-CoV-2 pandemic was incorporated in the study. As might be expected, most companies have seen their innovation capabilities hurt because of the global health crisis. The questionnaire used (see Appendix A) may be useful for future research aimed at establishing the level of openness and collaboration of agri-food companies or those operating in different economic sectors with external actors.

6. Conclusions

Open innovation, seen as a competitiveness strategy, is rapidly expanding among agri-food companies. Comprehensive literary reviews that compile empirical information and findings in different regions and subsectors are necessary to clarify the new paradigms with the specific challenges and opportunities in this sector.

Through a systematic literature review and a structured survey, this work allowed us to highlight potential opportunities offered by open innovation to micro, small- and medium-sized companies, particularly those related to better technology transfer processes and reduction of infrastructure and logistic costs derived from traditional innovation models; however, companies need an adequate innovation management system to get the most out of cooperative relationships with external partners.

The main challenges within the agri-food sector for this approach are related to the lack of government support, obsolete and poorly standardized regulations for the management of intellectual property, and communication barriers between involved parties.

The organization and application of a structured survey to a sample of 57 small- and medium-sized agri-food companies from Nariño, Colombia, was useful for the discovery of a clear positive correlation (Pearson) between two items: collaboration with various external actors and innovation performance of companies.

As a general conclusion, open innovation has multiple potential benefits for the competitiveness of companies. Additionally, it can promote a better cohesion and technological development in the agri-food systems and between all actors that are included.

Supplementary Materials: Complementary data to the results of the structured survey as the average values of all the items that make up the variables can be found in: https://www.mdpi.com/article/10.3390/joitmc7020161/s1.

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

Appendix A

Questionnaire used for the structured survey (Based on the methodologies from [44–46]).

1. Basic Data: Email address
   Company name
   Name of the person who answers this survey (NOT required)
   Position held in the company.
   Municipality
   Age of the company:
   - 1–3 years
   - 3–7 years
   - 7–12 years
   - 12–20 years
   - more than 20 years

   Company size (direct jobs):
   - 10 or fewer workers
   - between 11 and 50 workers
   - between 51 and 100 workers
   - between 100 and 250 workers
   - more than 250 workers

   At what level (s) of the food chain does the company operate?
   - Production (agriculture, livestock, fishing)
   - Processing and transformation (industry)
   - Sales/Marketing

   Note: Please watch the following video before answering the questions: https://www.youtube.com/watch?v=LlrUVde69VI&feature=emb_title&ab_channel=JhonWilderZarthaSossa (accessed on 28 June 2020).

2. General Innovation Skills
   - 2.1 Does your company's strategy take innovation into account and consider it a key factor for its success? (Yes/No/DK-REF)
   - 2.2 Does your company have a Research and Development Unit (R + D or R + D + i)? (Yes/No/Don't know or Refuse to answer)
   - 2.3 Has your company formulated or implemented an innovation strategy? (formal plan where the objectives, the actions to be carried out, the resources, and the budget necessary for the development of the innovation activities are defined) (Yes/No/DK-REF)
   - 2.4 Has your company carried out technological surveillance studies? (Yes/No/DK-REF)

2.5 Has your company developed or participated in open innovation processes? (Yes/No/DK-REF)
2.6 Does your company have an Innovation Model, Innovation Management Model, or Innovation Management System? (Yes/No/DK-REF)
2.7 The expenditure that the company allocates to research and development activities corresponds approximately to:

- 0% of the total turnover (income) of the company
- 1–2% of the total turnover of the company
- 2–5% of the total turnover of the company
- More than 5% of the total turnover of the company
- DK-REF

3. Platforms and Open Innovation Challenges
   3.1 Did you previously know the open innovation concept/system? (Yes/No/DK-REF)
   3.2 Do you know or have you heard of any of the following open innovation platforms?
   - SUNN (before watching the video)
   - Innocentive
   - Ninesigma
   - Moonshot
   - Ocean
   - Yet2
   - DK/REF (do not know/Refuse)
   - another...

   3.3 After watching the video, do you think the platforms and leftovers of open innovation could be useful in your company's business model? (Yes/No/DK-REF)
   3.4 After watching the video, would you consider linking your company to open innovation platforms to find solutions to your internal problems or challenges? (Yes/No/DK-REF)
   3.5 If you consider linking your company to open innovation platforms, do you think it would benefit more with an outside-in model (looking for knowledge and technologies abroad to apply it in your business), and inside-out model (exporting (commercializing) its own internal knowledge, thus helping other companies to solve their problems), or a mixed model (combining the two previous models)?
   - Outside-In Model
   - Inside-Out Model
   - Mixed Model
   - DK/REF

For each of the following cases, please rate how much the statement agrees with the current situation in your company on a scale of 1 to 5, 5 being TOTALLY ACCORDING TO THE COMPANY'S SITUATION and 1 being TOTALLY DIFFERENT TO THE CURRENT SITUATION OF THE COMPANY.

4. Collaboration with External Partners in the Innovation Process: Customer Participation
   4.1 We maintain regular communication with our clients to incorporate the information provided directly into our production processes (1-5-DK/REF).
   4.2 We involve our clients directly in the innovation process (1-5-DK/REF).
   4.3 We have effective relationships with our clients that allow us to implement better solutions to their needs using the most appropriate technology (1-5-DK/REF).
   4.4 We regularly conduct market research (e.g., surveys, target group analysis, etc.) to obtain more information about our clients (current and potential) (1-5-DK/REF).
5. Collaboration with External Partners in the Innovation Process: Supplier Participation

5.1 We maintain regular communication with our suppliers to obtain in-depth knowledge about their ongoing technological developments (1-5-DK/REF).
5.2 We actively involve our suppliers in the process of developing new products or improving processes (1-5-DK/REF).
5.3 Our suppliers play an important role in our product development activities and/or operational processes (1-5-DK/REF).
5.4 We encourage cooperation in Research and Development (R&D) with our suppliers to configure our activities of product development, process improvement, or technology acquisition more effectively (1-5-DK/REF).

6. Collaboration with External Partners in the Innovation Process: Participation of Competitors
   6.1 Within the development of new products or technological improvements, we align ourselves with selected competitors to accelerate development processes and share costs (1-5-DK/REF).
   6.2 We carry out R&D cooperation with competitors to take advantage of synergies, if they are not key or sensitive knowledge (1-5-DK/REF).
   6.3 We exchange information with competitors and reach benchmarks with them to stay up to date with the latest technological developments and trends (1-5-DK/REF).
7. Collaboration with External Partners in the Innovation Process: Participation of Universities
   7.1 We maintain constant R&D cooperation with universities to jointly develop new technologies and new products and/or to improve our productive, logistical, or organizational processes (1-5-DK/REF).
   7.2 We maintain regular communication with universities to always be up to date with the latest technological inventions related to our business (1-5-DK/REF).
   7.3 In case we experience technological problems related to product development processes or our operational logistics, we usually work closely with universities to find solutions (1-5-DK/REF).
   7.4 The regular exchange of information with universities and the technology transfer process are important to our firm (1-5-DK/REF).
8. Collaboration with External Partners in the Innovation Process: Participation of Independent Experts
   8.1 We work together with independent experts (e.g., public research institutes, engineering consultants, companies specializing in technology, etc.) in terms of contractual agreements to solve technological problems within the development processes of new products and/or operational or logistical processes (1-5-DK/REF).
   8.2 We regularly contact independent experts in the innovation process (products, processes, organizational improvements) (1-5-DK/REF).
   8.3 In the context of new product development processes, we work with institutions (e.g., public research institutes, engineering consultants, specialist companies, etc.) and people with special knowledge to take advantage of their ideas (1-5-DK/REF).
   8.4 Regular knowledge exchange with independent experts is important to our company (1-5-DK/REF).
9. Performance Measurement: Performance in Innovation
   9.1 We bring new and innovative products to the market or implement new operational or organizational processes more frequently than other companies in the sector (1-5-DK/REF).
   9.2 In our market, we are known for our innovative products and processes (1-5-DK/REF).
   9.3 Our new products differ substantially from their predecessors.
   9.4 The percentage of new and innovative products in the product portfolio is significantly higher compared to our competitors (1-5-DK/REF).

9.5 We open new markets more frequently than our competitors (1-5-DK/REF).
9.6 The percentage of sales generated through new and innovative products is significantly higher compared to our competitors (our new products are better received) (1-5-DK/REF).

10. Performance Measurement: Propension to Innovation
    10.1 When was the last time the company incorporated a new technology into its core business?
    - Less than 1 year ago
    - Between 1 and 2 years
    - Between 2 and 3 years
    - Between 3 and 5 years
    - More than 5 years ago.
    - DK/REF

    10.2 When was the last time the company started selling a new product?
    - Less than 1 year ago
    - Between 1 and 2 years
    - Between 2 and 3 years
    - Between 3 and 5 years
    - More than 5 years ago.
    - DK/REF

    10.3 When was the last time the company changed its organizational structure? Less than 1 year ago
    - Less than 1 year ago
    - Between 1 and 2 years
    - Between 2 and 3 years
    - Between 3 and 5 years
    - More than 5 years ago.
    - DK/REF

    10.4 When was the last time the company changed its distribution or marketing channels?
    - Less than 1 year ago
    - Less than 1 year ago
    - between 1 and 2 years
    - between 2 and 3 years
    - between 3 and 5 years
    - More than 5 years ago.
    - DK/REF

11. Effects of the Pandemic (Covid-19) on Innovation The global emergency due to the Covid-19 virus has affected all sectors of the economy to a greater or lesser extent. Please answer the following questions to find out its repercussions in the agri-food sector.
    11.1 How has the pandemic affected your company in the following aspects? (Scale between -3 (very negative effect), 0 (no effect) and 3 (very positive effect)):
    - Budget for Innovation
    - Innovation Capabilities
    - Customer relations
    - Relationship with suppliers
    - Closing or opening of new markets
    - Participation in innovation challenges
    - General performance of the company

11.2 How do you think the pandemic will have affected your company in a ONE YEAR horizon? (Scale between −3 (very negative effect), 0 (no effect) and 3 (very positive effect)):

- Budget for Innovation
- Innovation Capabilities
- Customer relations
- Relationship with suppliers
- Closing or opening of new markets
- Participation in innovation challenges
- General performance of the company

11.3 How do you consider that the pandemic may affect the following processes in the agri-food sector of Nariño?)Scale between −3 (very negative effect), 0 (no effect) and 3 (very positive effect)):

- Generation of new technologies
- Technology transfer
- Absorption of new technologies
- Adaptation of new technologies
- Diffusion of new technologies

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