

Review

Analysis of Scientific and Technological Perspectives on the Development of New Food Products from Family Farming

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Abstract: This study aimed to identify the development of new food products related to family farming from scientific and technological perspectives. Data were collected from the scientific literature and patent documents in the Scopus and National Institute of Industrial Property databases, using a combination of terms, such as “family farm* OR small-hold farm* OR agricultur* farm* labor OR farm* size OR peasant farm* OR agriculture* food* product* AND food* product*”. The asterisk (*) denotes a truncation character used in articles and patent databases to perform a search using multiple terms with the same root but different suffixes. A total of 716 articles and 532 patents were identified. The data from the scientific articles provide an overview of family farming participation in the development of food products and how products that are developed by family farmers resonate with society. The patent documents found showed the development of innovative production technologies, such as machines and production methods to improve the quality of the products sold by family farmers. Therefore, there is great potential for family farming foods to advance in this technological area, with the prospect of increasing publications and new patent applications related to this subject.

Keywords: family farm; food products; technological innovation; analysis



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1. Introduction

Family farming is defined as the cultivation of land by small rural landowners whose workforce is essentially the family nucleus, which combines family, agricultural, and commercial activities [1]. In family farming, the division of labor is generally based on the complementarity between people of different genders and generations [1].

In Brazil, family farming emerged as an alternative to monoculture and large estates in the colonial period, strengthening itself with the social, cultural, and environmental impacts caused by the “green revolution” from the 1950s and onwards. Owing to its intrinsic link to food security and nutrition, family farming not only drives local economies but also contributes to sustainable rural development by establishing an intimate relationship and lasting bonds between the family and its living and production environment [2,3].

Family farming is responsible for 23% of the entire Brazilian agricultural production, wherein 76.8% are family-based rural establishments [4]. However, family properties only

account for 23.0% of the total area of agricultural activities [4]. The limited size compromises the financial viability of these establishments as the scale of production becomes a structural problem for farmers [4].

Globally, family farming represents approximately 35% of the global food production, even with the increase in industrialization and urbanization [5]. More than 608 million family farms exist worldwide, accounting for 70% to 80% of the total agricultural land [5]. In family farming, people cultivate products for their own needs and cultivate other products under different natural, economic, and political conditions, thus creating a basis for a self-sustaining family and community life and a product that can be sold in the market [5].

Despite the outstanding economic and social importance of family farming worldwide, family properties stand out in terms of their low technological level, mainly due to the type of social organization, poor access to information, small available workforce, inadequate infrastructure, and location of properties, and are increasingly influenced by the market for its products and investments in land and other resources by non-family interests [2]. Therefore, the family farming sector should respond to technological changes and market forces, which will provide innovative technological alternatives to contribute to added product value, income generations, improved quality of life, and consequently the maintenance of economic viability establishments [6].

According to Dogliotti et al. (2014), values besides economic ones should be considered to be related to the importance of family farming, which highlights the maintenance of stable communities and rural populations in countries, in addition to the direct contribution to the maintenance of natural resources in which agricultural families are based [7].

According to Bittencourt (2020), family farmers face difficulties in improving their ability to enter local markets through innovation, adoption of technologies, and establishment of socio-technical networks and cooperatives, demystifying the historical heritage of family farming, which is subsistence agriculture focused solely on family consumption. As a result, the development of innovative food products from raw materials produced by family farming is an important tool for innovation and market access in this sector [2].

A technological and scientific prospection study on the development of innovative products from family farming can help to identify the potential of technologies created for the sector, and scientific elaborations help to formulate strategies for new developments and promote the establishment of public policies that provide greater socio-economic benefits [8]. Prospecting is essential to identify more relevant needs and opportunities for research and development in the future [9].

Scientific and technological analysis corroborate the objective of this study, which is to identify the development of new food products related to family farming. It is an innovative study, bearing in mind that there is no analysis in the literature of technological solutions to expand the range of new products for the development of family farming, which is a very important instrument, as it can help farmers to introduce new technologies, promoting the development of their farms, expanding the assortment of products offered and increasing the economic efficiency of production.

2. Materials and Methods

This research was performed using scientific articles and patent documents, and the collection of data published between 1952 and 2021 was carried out in July 2021 for analysis. A total of 1248 documents were selected (Figure 1), including articles and patents related to food products and family farming. The information collected was then tabulated.

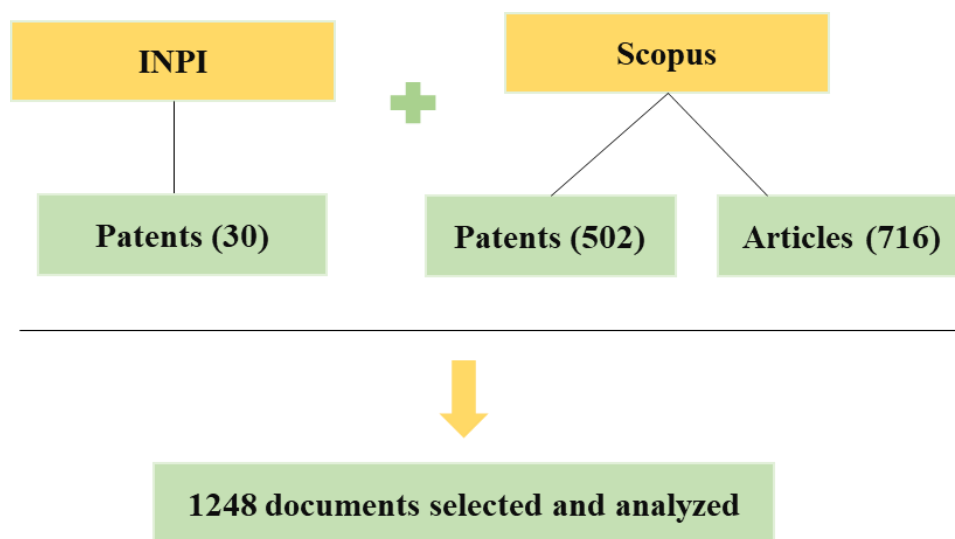


Figure 1. Flowchart for the selection of patents and articles.

2.1. Scientific Articles

Scientific articles were obtained via a search of the Scopus database using the same terms used in the search for patent documents, namely: “family farm* OR small farm* OR agricultur* farm* labor OR farm * size OR peasant farm* OR agricultur* food* product* AND food* product*”. The asterisk (*) denotes a truncation character used in articles and patent databases to perform a search using multiple terms with the same root but different suffixes. Scopus is a multidisciplinary bibliographic database created in 2004 by Elsevier. This database includes abstracts and citations but not full texts. The search covered journals, books, periodic scientific work of events, and patents. A total of 716 scientific articles were collected. For all articles found, the year of publication, affiliation (institution where the main author is linked), author, country of origin, area of application, and main terms related to family farming that were used in these documents, in addition to the development of new food products by family farming, were recorded. The exclusion criteria were not applied to the selected articles, which were articles that provided an overview of the participation of family farming in the development of food products, either in the product itself or in the elaboration process. Graphs were generated, and the obtained information was discussed.

2.2. Patent Documents

The search for patent documents for food products related to family farming was carried out in two patent databases: Scopus and the National Institute of Industrial Property (INPI). Five patent offices are indexed in Scopus: United States Patent and Trademark Office, Japan Patent Office, European Patent Office, World Intellectual Property Organization, and United Kingdom Intellectual Property Office. Although the INPI is a Brazilian patent office, it was used to clarify how the Brazilian innovation system sought by the theme is structured.

The terms used to collect the documents in the databases were the same used to search for scientific articles, mentioned in Section 2.1. Data collection was carried out in the search field “article title, abstract, keyword” in Scopus and the “abstract” field in INPI. A total of 532 patent documents were found, wherein 502 were collected from Scopus and 30 from INPI.

Patent documents were analyzed by identifying the years of patent filing, applicants, inventors, international patent classification (IPC) codes, country of origin, area of application, and the main terms for family farming used in these documents, in addition to the development of new food products by family farming. Pertinent information was extracted from each document and discussed herein.

Figures were generated using GraphPad Prism (version 7.0), Microsoft Excel, and PowerPoint, in addition to graphical sites for the elaboration of other images and MENTI-MENTER (www.mentimeter.com—accessed on 22 October 2021).

3. Results and Discussion

3.1. Terms Related to Family Farming

There are several terms that are related to family farming, so it is necessary to identify the main terms used and therefore expand searches for studies on this topic. In this study, “family farm”, “agricultural”, “agriculture”, “agricultural food product”, and “small-holder farming” were the mainly used terms in scientific articles associated with family farming. For patents, the most common terms were “agricultural food product”, “smallholder”, and “family farming”. The terms are related to the definition used for family farming, mainly the form of production of small farmers in small rural properties and on a small scale.

3.2. International Patent Classification

The IPC codes are a system standard for the organization of knowledge for technological innovation. Patent documents are classified by specialists in the area in accordance with the code of the relevant technological area [10]. This system is sufficiently used by researchers and scientists to recoup the state of the art and analyze the technological field of the definitive patent sector.

The analysis of patent documents, in accordance with the classification of the codes used, revealed that most patents had been registered in subgroup A23K50/10, which represents the nourishing products for ruminants and the method of production of the same ones (Figure 2). The scenario of the scientific articles discussed also reflected this, as authors that published the greatest number of articles on the studied topic referred to the production of animal feed. A23K50/80 and C12N1/10 were the subgroups with the largest number of deposits, with mentions of nourishing products especially adapted for aquatic animals, such as fish, crustaceans, or clams; the method of production of the same ones; and the processes of propagation, maintenance, or conservation of protozoa and their ways of culture, respectively.

The owners of family farms search for different strategies to increase their income, such as diversification in food cultivation [11]. Therefore, the development of products directed toward animal creation becomes a necessity, as creation and possible commercialization are sources of income for these agriculturists.

3.3. Application Areas of the Articles and Patents

With regard to the area of application, it is important to understand where the interest in articles or patent documents is focused, as it indicates whether the area of technology being searched for is developed or under development, when they have a large and small percentage, respectively.

The main areas of application could be determined for articles referring to family farming (Figure 3a). The most common area of application was “agriculture and biological sciences”, which was listed in 20% of the papers, followed by “social sciences”, which was listed in 17% of the papers. Approximately 18% of the studies did not specify the application area. According to IFAD (2011), family farming is responsible for a significant part of the world’s food production. Accordingly, family farming is responsible for meeting the growing needs of the world population in relation to food production. Accordingly, family farmers have sought to develop more productive, profitable, resource-efficient, and environmentally friendly agricultural systems [12]. This fact justifies the higher percentage of articles, and consequently, scientific research in the area of agriculture and biological sciences, where studies involving soil, agricultural production methods, among others, are conducted.

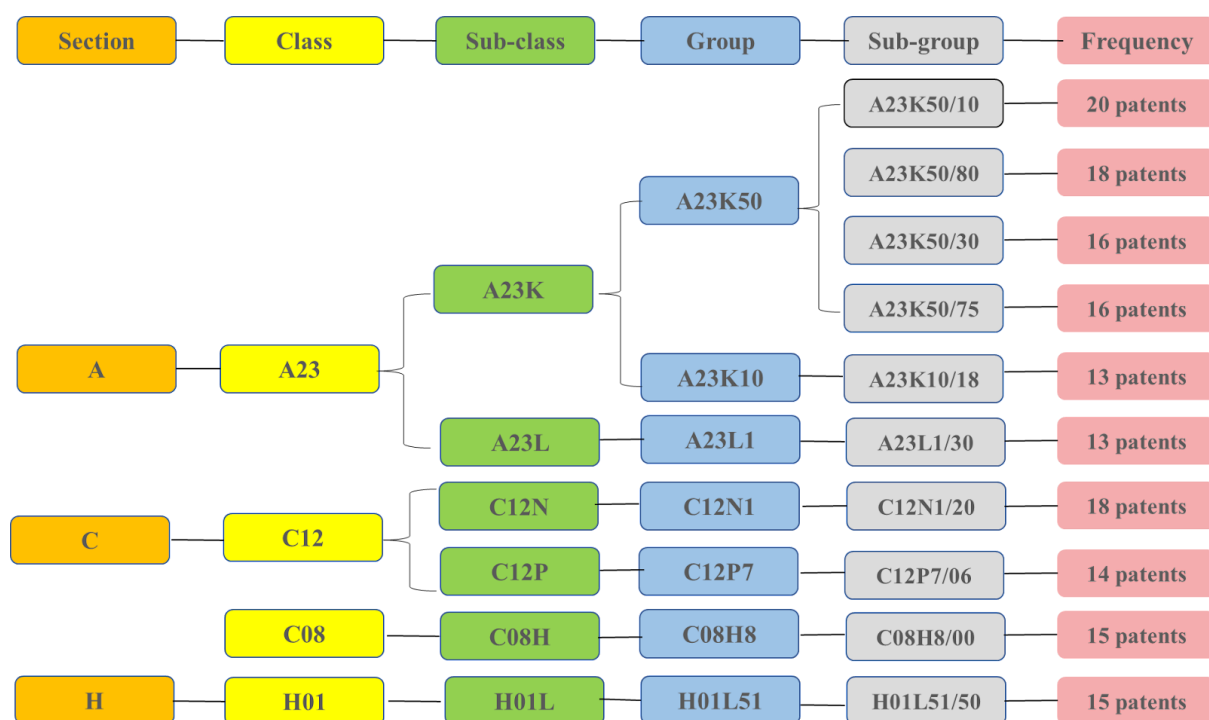


Figure 2. Top 10 number of patents filed on the participation of family farming in the development of new food products, according to their IPC codes.

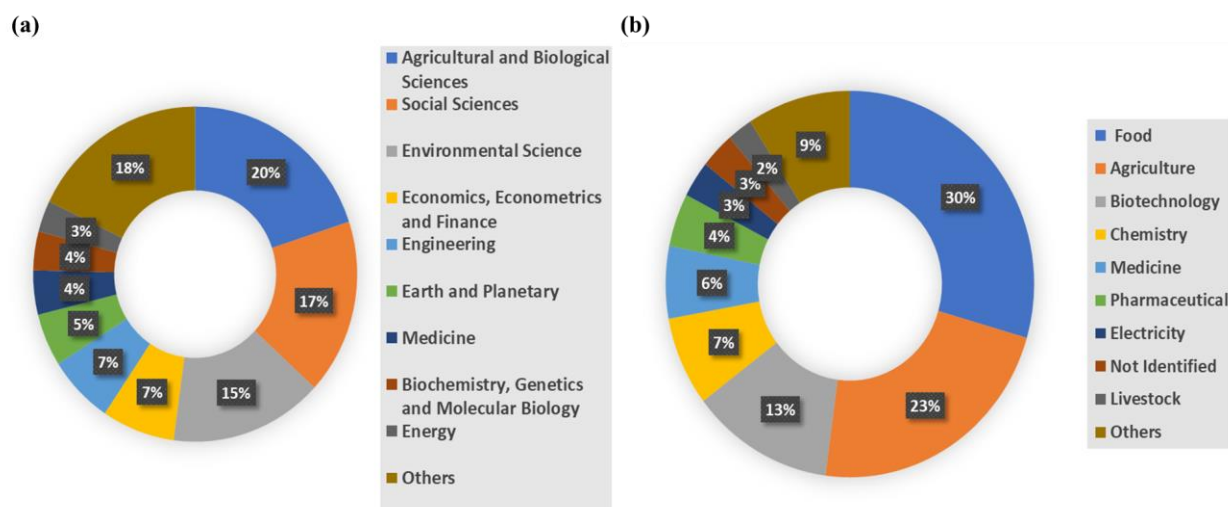


Figure 3. Areas of application for the published articles (a) and patent documents (b) on the participation of family farming in the development of new food products.

The socio-economic context directly affects family farming, and maintaining income is a strategy for most farmers. Thus, continuous specialization and intensification of their production systems are essential activities for farmers [7]. Therefore, research and innovation in the area of family farming have undergone a process of technical and even institutional changes that enable greater productivity, sustainability, and poverty reduction [13]. These factors can justify the large percentage of papers related to family farming and the “social sciences” application area, which includes studies on the social aspects of the field.

Based on an analysis of the patent documents related to family farming, the main areas of application are related to the food industry (30% of patents), followed by the agriculture sector (23%) and biotechnology (13%) (Figure 3b). Other prominent application

areas include chemicals, medicine, and pharmacology. These results demonstrate that the food industry is the largest holder of technology in family farming, and the filed patents are mainly related to the development of innovative products from raw materials produced by family farming. This fact highlights the remarkable potential for the development of innovative food products from family farming. Patents related to the agricultural application area are more related to the development of innovative technologies for agricultural production, including machines and forms of production. In the biotechnology field, there is a predominance of fertilizer and pesticide development.

These innovations in the area of family farming vary between countries. Further, within the same country, these innovations vary according to region. Such variation is because the organization of family farmers varies according to regions and even with the availability of certain raw materials. Therefore, the development of technologies and research are based on the needs and possibilities of family farmers in each region [14].

3.4. Annual Evolution of Articles and Patents

The purpose of the annual evolution is to identify how the situation is over the years, and whether the subject matter is growing or not. Therefore, this section will discuss the annual evolution of articles and applied patent documents.

The participation of family farms in the development of new nourishing products was disclosed in 716 articles and 532 existing patents. Figure 4 shows the scientific and technological advances in the participation of family farms from 1954 to 2021 for scientific articles and 1964 to 2019 for patent documents. Analysis of the annual evolution of these documents is an important instrument for explaining and correlating trends in the evolution of scientific and technological information in the productive sector of family farms.

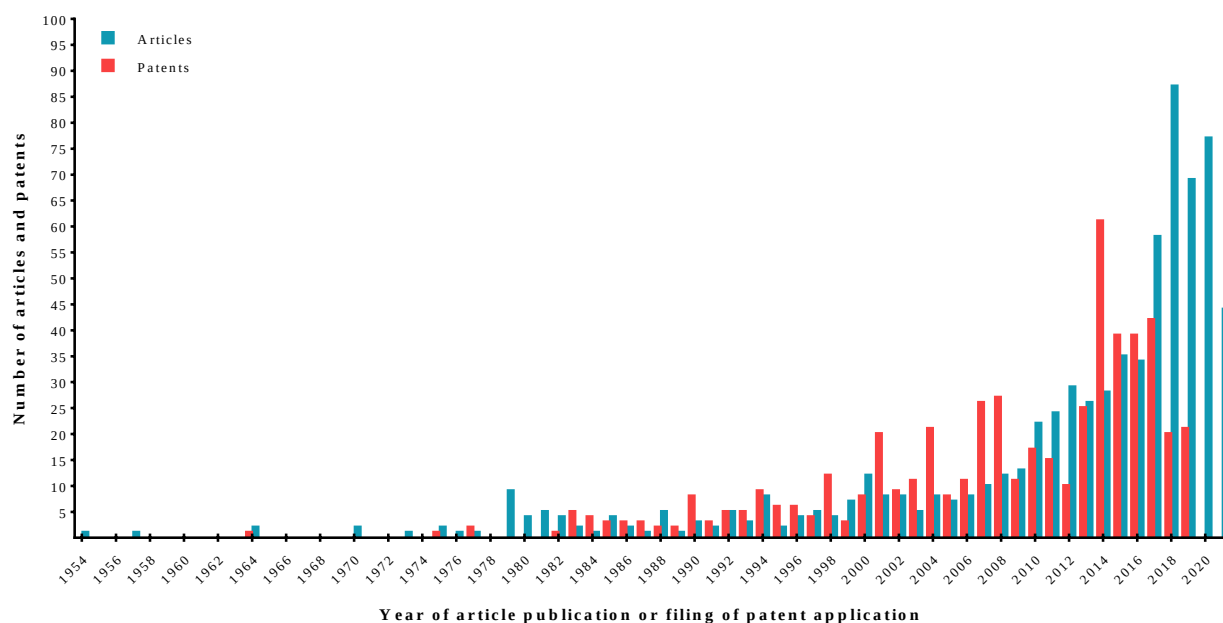


Figure 4. Number of published articles and patent documents filed regarding the participation of family farming in the development of new food products, between 1954 and 2021.

The first scientific article on the subject was shared in the 1950s, specifically 1954, at a conference in Aberdeen, a Scottish city, which involved presentations related to the exploitation of fish and agri-food products, particular the utilization, milling, and production of oat-based products (produced for small family farms), in addition to the quality of new by-products developed from fish [15].

As shown in Figure 4, scientific growth owing to family farming in the development of food products began in 2000, with more than 50% of scientific articles published from

2015 onward. The highest number of scientific publications was published from 2018 to 2020, with the most published in 2018 (i.e., 87 articles).

The increase in scientific publications from 2015 can be explained by the commitment of countries that are part of the financial group G20, which comprises 19 bigger economies of the world, and is represented by the ministers of finances and heads of the central banking [16]. The G20 group committed to increasing the sustainable form of agricultural production, investing in agriculture, mainly in poor countries, and considering the importance of small agriculturists, investing in research and development in agricultural productivity [16]. This remarkable increase may also be related to a greater concern for the ingestion of healthier and pesticide-free foods. Therefore, a greater interest in consuming family agricultural products was awakened in this period, as such products are considered to be healthier and more natural by the population. Consumers also value such activity [16].

The first patent on the participation of family farms in the development of nourishing products was registered in 1964, in the United States (US3292584) [17]. This patent was related to the development of methods and means of production of animal feeding, an activity that has a great role in family agriculture and rearing of animals [17]. However, a significant growth in the deposit of these patents began in 2001. In 2014, the largest number of patents (61) was registered.

The intensification of support for family farmers from many countries, either responding to the demands of the agriculturists or including this subject in its strategic agendas [16], has fundamental importance for the advancement of the technological sector in the development of new nourishing products from family farms. The boost of agricultural growth has garnered sufficient arguments in developed and developing countries due to increasing demand for foods and jobs, beyond the great concern of climatic changes [18,19]. These changes are possible causes of the increase in the average temperature of the Earth, which may shift the precipitation standards and induce a bigger frequency of extreme climatic events, which places alimentary security in a state of alert [10]. Accordingly, bigger incentives in research and development of sustainable food have become necessary.

In Brazil, 30 patents were found to be related to the subject, with six documents registered in 2017. Brazil has significant importance in the agri-food sector worldwide, as it is a great agricultural food exporter, with a significant average income in the family farm sector, mainly in the domestic market [20]. However, the incentives for research and development are still low compared to the agricultural potential of the country.

Since 2020, patents have not been registered in any of the two analyzed databases. This result might be related to a shift in the efforts of researchers and scientists to the study of COVID-19 [21]. Moreover, the lack of patent deposits from 2020 can be related to the period of secrecy associated with the filing of a patent, which occurs before the actual patent is granted.

3.5. Family Farming in the Development of New Food Products

Family farming is well known for its diverse contribution to food production [22]. A series of scientific productions also seek to develop and use agricultural products marketed by family farming. Table 1 presents some of the scientific productions obtained via the analysis, production, or commercialization of agricultural products produced or sold by small farmers.

Table 1. Main information on articles that reported the direct role of family farming in the development of new food products.

Title	Study Objective	Participation of Family Farming	Ref. *
Quality and storability of common beans in small-holders farm stores in Northern Tanzania: A multivariate analysis of agro-location, variety, and storage method effects	Investigate the interactions between variety and storage method of grains marketed by family farmers, with a focus on improving quality.	Family farmers will benefit as they will produce higher quality grains to help with family income.	[23]

Table 1. Cont.

Title	Study Objective	Participation of Family Farming	Ref. *
The performance of municipalities of Rio Grande do Sul in the implementation of the resources of the PNAE with family agriculture	Analyze the performance of the municipalities of Rio Grande do Sul (BR) from 2011 to 2016 in relation to the investments made in the acquisition of food products from family agriculture for school feeding.	Evaluate the performance of investments made in pharmaceutical products from family farming, in addition to assessing the relationship between family farming and institutional markets.	[24]
Microbiological and physicochemical profiles of the sour cassava starch and bagasse obtained from cassava agroindustry	Evaluate the microbiological and physicochemical qualities of sour cassava starch and cassava bagasse produced in the cassava agroindustry to assess their potential for use in food.	All samples by producers were provided by family farmers to establish a partnership and enable an analysis of the products cultivated and marketed by farmers.	[25]
Menus and sustainability: Essay on the guidelines of the National School Food Program	Discuss the menu incorporated in the School Feeding Program guidelines, with focus on the purchase of food generated using products sold by family farmers.	Products used to prepare school meals should be purchased from family farmers.	[26]
A Study on Implementing Food Safety Management System in Bottling Plant	Analyze the implementation of the Food Safety Management System to ensure safety in the black carob honey production process used by family farmers.	Family farmers are responsible for guaranteeing not only the quality of the raw material obtained through good beekeeping practices in primary production but also the manufacturing process of a healthy final product (locust bean honey) that confirms its labeling.	[27]
Evaluation of the acquisition of food items from family farming for school meals	Evaluate the purchase of food from family farming by the municipalities selected to receive the award.	The realization of the study and the award are extremely important for enhancing and encouraging the acquisition of products produced via family farming.	[28]
Shrinkage of carrots during drying in an inert medium fluidized bed	Determine the effects of different physico-chemical parameters of agricultural products sold by family farmers.	The analyzed products were cultivated by family farmers and were evaluated to improve the quality of these products and increase sales.	[29]
Agricultural production: Synopsis of employed quality control methods for the authentication of foods and application of chemometrics for the classification of foods according to their variety or geographical origin	Review quality control methods and applications of multivariate statistical techniques on the authentication and classification of agricultural products produced by family farmers.	Development of quality control for agricultural products	[30]
The production of poultry in integrated aquaculture agriculture systems: Part II: The integration of laying hens with fish and vegetables in integrated aquaculture-agriculture food production systems	Investigate the growth and production of Peking and Musk ducks in ponds using nutrient-enriched water from an intensive fish production system that recirculates water.	The incorporation of laying hens in an integrated aquaculture-family farming food production unit was investigated.	[31]
Applying agroecology to enhance the productivity of peasant farming systems in Latin America	Analyze the application of agroecology in traditional farming systems and animals to increase productivity, thereby biologically restructuring peasant farms.	The application of agroecology leads to the optimization of the main agroecosystem processes (nutrient cycling, accumulation of organic matter, biological pest regulation) and efficient use of labor and local resources, benefiting small farmers.	[32]

* Ref.—reference.

The articles mainly discussed the sale, commercialization, and impact of the products developed by family farmers on society in general to evaluate their acceptability and identify possible strategies that help in the introduction of these products in the market and improvements in them. In the aspect of food production, these products make life easier for family farmers (strategies to improve the soil for climate adaptation), without removing the production characteristics [33–35].

The development of food products by family farmers is a promising topic; however, only a few records detail this development. In the scientific field, a massive production of technologies and investigations have been carried out to improve the quality of food produced by family farming; this is because small farmers usually do not have enough machinery to aid such production. These technologies assist in this process and in the commercialization of these products, thereby improving product characteristics [30,32,36–40].

Many organizations work with family farmers to promote the commercialization of their products. Among the articles analyzed, the National School Feeding Program was identified to be directly linked to the acquisition of agricultural products developed by family farmers [24,26,28]. One of the articles in Table 1 sought to precisely investigate the process of acquiring these foods by municipal schools in Rio Grande do Sul [24]. The process of acquiring food produced by family farmers is increasing and is a theme that has potential for further development; this is because society is increasingly seeking food produced via a sustainable food system, in its entirety, and family farming is closely related to this production lineage.

When the selected patent documents were analyzed judiciously, only 7% were found to have a direct association with family farms that actively participate in the development of new nourishing products. Table 2 presents some examples of patent documents that have revealed the participation of small agriculturists in the production sector of nourishing products.

Table 2. Main information on patents that reported the direct association of family farming in the development of new food products.

Title	Indication of Use	Technology/Product Protected	Participation of Family Farming	Patent Document	Ref. *
Freshness retention of agricultural food product	Improvement in the conservation of fresh products	Development of a method to maintain the freshness of agricultural food products, such as harvested vegetables	Protection of fresh food grown by family farming	JP2000157161	[41]
Preservation of food	Storage of agricultural food	Method of storing agricultural foods, such as grain, to maintain their qualities for a long period of time and enable preservation of the agricultural food in a space at a specific temperature and a prescribed humidity	Agricultural food developed by family farming	JPH09294535	[36]
Sapoti extra jelly (Manilkara zapota) and umbu cajá (Spondia tuberosa x Spondia mobin)	Generation of food products	Development of a product, particularly sapodilla jelly and umbu caja	The development of this product can be an employment opportunity and source of income for small local farmers. The product can also be incorporated into various preparations.	BR 10 2019 018953 3 A	[42]

Table 2. Cont.

Title	Indication of Use	Technology/Product Protected	Participation of Family Farming	Patent Document	Ref. *
Preparation of additional functional goat yoghurt from passion fruit (<i>passiflora edulis</i> Sims.) and mandacaru fruit (<i>cereus jamaru</i>)	Generation of food products	Functional goat yogurt containing passion fruit jelly and mandacaru, depending on the constituents added in the preparation, may possess probiotic, prebiotic, and symbiotic characteristics.	This product is a potential alternative for small farmers to generate income, expand their agribusiness, and add value to local and regional ingredients.	BR 10 2017 020281 0 A	[37]
Preparation and processing of functional yoghurt ice cream	Generation of food products	Preparation of a product that can exert a functional effect through the addition of lactic cultures (starter and <i>L. paracasei</i>) and prebiotic fiber (oligofructose), flavored with fresh passion fruit jelly	Family farming actively participates in the manufacture of this product, providing the milk obtained from their goats	BR 10 2019 001298 6 A	[38]
Process of obtaining and use of jucá stem hull flour and the fruit <i>Libidibia ferrea</i>	Generation of food products	Preparation of a new natural product, with a pleasant taste, without the addition of preservatives and flavorings, that has a high carbohydrate and mineral content to serve consumers who seek a healthy diet	Possibility of adding value and promoting income generation, mainly for family farming, as this vegetable grows spontaneously	BR 10 2019 001421 0 A	[39]
Process of obtaining a biscuit-based food product enriched with rice flour and final product	Generation of food products	Preparation of a biscuit for commercial application in the food industry, with the main advantage of offering the market a nutritious product with good acceptance, free from gluten, thereby stimulating legume production via family farming	Family farming provides one of the main ingredients of the developed biscuit, which is a possible source of income	BR 10 2017 010394 3 A	[40]
Process for obtaining functional food composition in the form of cereal bar based on bean flour and final product	Generation of food products	The cereal bar is a food composition that serves as a nutritional and functional alternative	Product prepared to reduce the post-harvest losses of small farmers, add value to regional foods, and contribute to local eating habits	BR 10 2017 010393 5 A	[43]

* Ref.—reference.

The patent document JP2000157161 was recovered for this prospect. The industrial application of this patent is the food sector; this patent is a method to keep the cool ones of the alimentary agricultural products, such as harvested vegetables [41]. Family farms are mainly responsible for the culture of fruits and the vegetables in Brazil [44]. However, many of their foods produced end up getting lost, unintentionally; this is due to inefficiencies in the production and supply chain, deficiency in the logistic infrastructure, lack of technology, and insufficiency in the abilities, knowledge, and capacity of management [45].

An attractive product patented for BR1020190189533 (A) was produced from cool fruits of sapodilla and umbu cajá during an adequate period of maturation for processing

and involves family farms. Therefore, this product can be cultivated by small agriculturists, thereby creating jobs and income for small local agriculturists and can be incorporated into diverse preparations [42].

One of the cited patents deposited for BR1020190012986 (A) protects the generation of yogurt ice cream produced from goat milk; this product has a functional effect through the addition of lactic cultures (the starter and *L. paracasei*) and prebiotic fiber (oligofructose), flavored with passion fruit jelly [38]. The rearing of goats is a farming activity with economic importance in Brazil, especially in family farms, and represents a source of income for the families [46].

Family farms often aim to produce food to meet increasing internal demands and contribute to regional and sustainable development [47]. Cultivation by small agriculturists supports the local consumer market and can be inferred to offer healthier foods for the population and generate products with less impacts on the environment [48–50]. However, related to the concept of sustainable development, the importance of family farms has been considered as a basic element for the production of new sustainable nourishing products, generation of job and income for alimentary security and local development [47].

3.6. Countries of Origin of Articles and Patents

In order to obtain data on the global scenario of new products for family farming, this section will discuss the countries of origin of articles and patent documents. From these data, it can be identified which continent is developing this subject most, as well as which countries contribute most to the expansion of this technology. In general, the impact of this topic can be observed globally.

According to the Food and Agriculture Organization of the United Nations, approximately one-third of the food produced worldwide is obtained from family farms [50]. The contribution of small farmers varies between countries. For example, in China, the participation of small farmers to the total production is approximately 80%, whereas in countries such as Brazil and Nigeria, small farmers have a lower contribution to the total food production. Furthermore, 70% of the world's farms are estimated to operate on 7% of agricultural land with less than one hectare, while 1% of farms operate on 70% of the world's agricultural land with more than 50 hectares, 40% of which are farms larger than 1000 hectares [50,51].

Data on farm size are important for countries wishing to invest in public policies that support small farmers, which can increase the productivity of family farming. Moreover, a large correlation exists between farm size and income in countries, with larger farm size in countries with higher income levels [50], such as the United States and the United Kingdom, which have a large share of agricultural area in large farms [52]. Furthermore, family farms are not necessarily small [52]. In fact, there are family farms with larger hectares of land; however, most farms are small [52].

Although most of the published articles related to family farming were obtained from Europe and Africa, the countries that present the greatest individual contribution with published articles for the area are the USA and Brazil, respectively (Figure 5a). One of these articles was written by the Brazilian author Suzi Barletto Cavalli, who highlighted the impact of COVID-19 on family farming. Based on the article, this sector could suffer from the closure of free fairs and lower demand for food from family farms. However, as discussed in this study, to minimize such occurrence, bill 735/2020 was approved in Brazil, which guarantees the maintenance of public purchases of food from family farms, and the provision of some basic services for the sector. Brazil is the top Latin American country that publishes articles involving family farming, with approximately 69.2% of the total articles published by Latin countries [53].

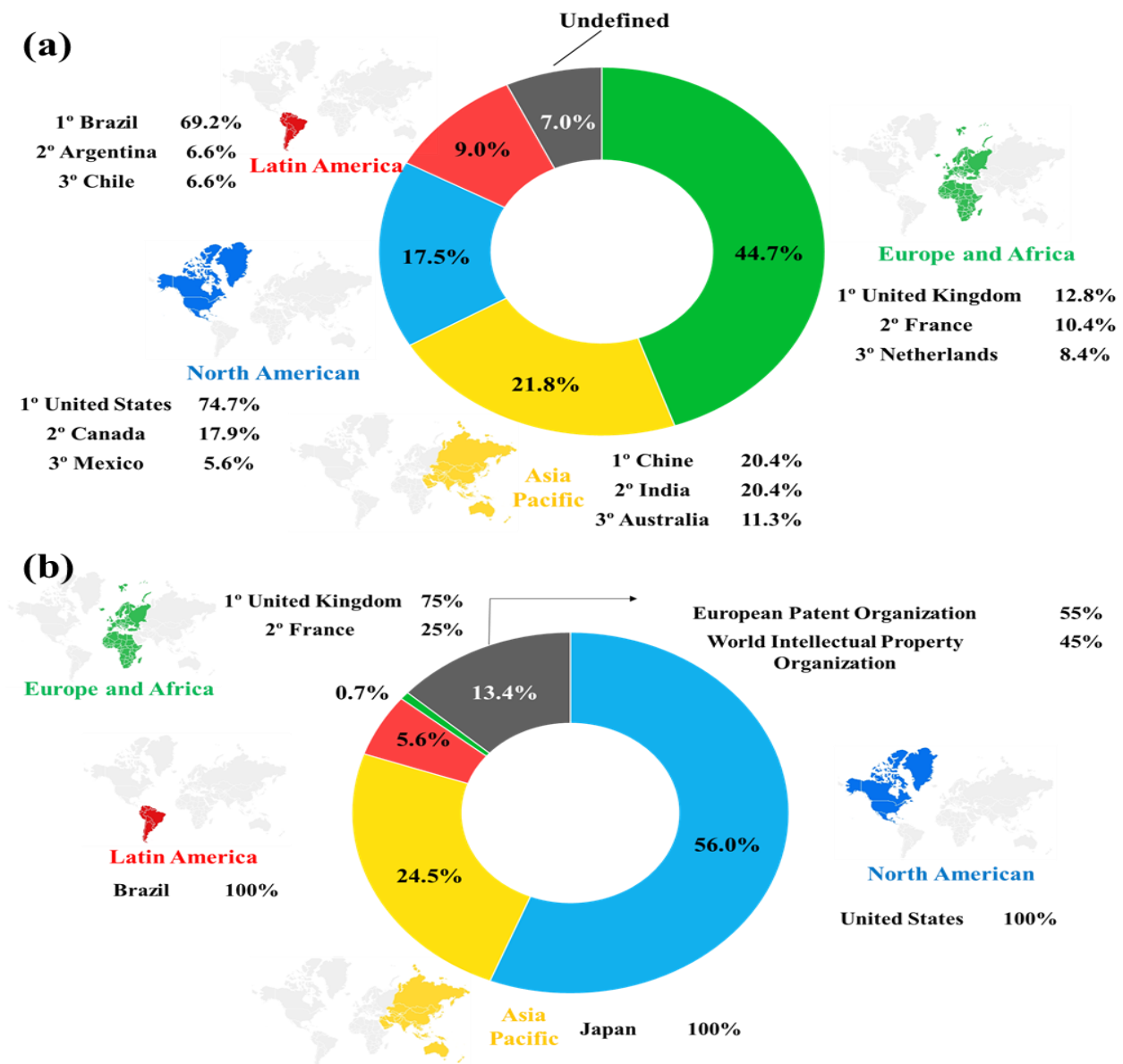


Figure 5. Number of articles published (a) and patents deposited (b) related to the participation of family farming in the development of food products, according to the country of publication or deposit.

According to the United States Department of Agriculture, small farmers are affected by COVID-19 and have suffered a loss of income [54]. However, programs that support farm income and benefits from state and local programmers for off-farm income flow disrupted by the pandemic have been established [54]. Therefore, the increasing number of articles may be due to the efforts of countries to minimize the consequences of COVID-19 in this area.

As depicted in Figure 5b, the North American continent has the highest percentage of patent deposits (56%), with most submitted by the United States of America. This result can be explained by the significant increase in small properties in the US, as well as in Brazil, which corresponds to 100% of the patent applications filed in Latin America. Notably, there is an increase in the agricultural land controlled by large farms in both the countries [55]. In addition, East Asian countries, except China, account for a 44% share in food production; this high rate may be due to the submission of 24.5% of patent applications by Asia-Pacific (Japan). Due to growing agricultural production, more inventions are patented to help improve family farming [52]. The patent offices, the European Patent Organization, and

the World Intellectual Property Organization were responsible for 13.4% of the patent documents filed on the subject.

3.7. Authors of Articles and Inventors of Patent Documents

In order to identify who are the pioneers that most develop new products for family farming, this section will discuss the main authors and inventors of this technology.

The data shown in Figure 6a infer that the scenario of authors and inventors is related to the country of origin. Alain Ronzano published the most articles, with 18 publications found in the search, and is affiliated with a French electronic bulletin called *L'actu-concurrence*. His articles were related to the French agricultural sector and bills, which can inform family farms on the sector. France is the second largest country in Europe for the publication of articles related to family farming. However, there was a decline in the number of family farms in the country, which may be due to the low attractiveness of the agricultural profession, growth in production, and fragility of land regulations [56–58].

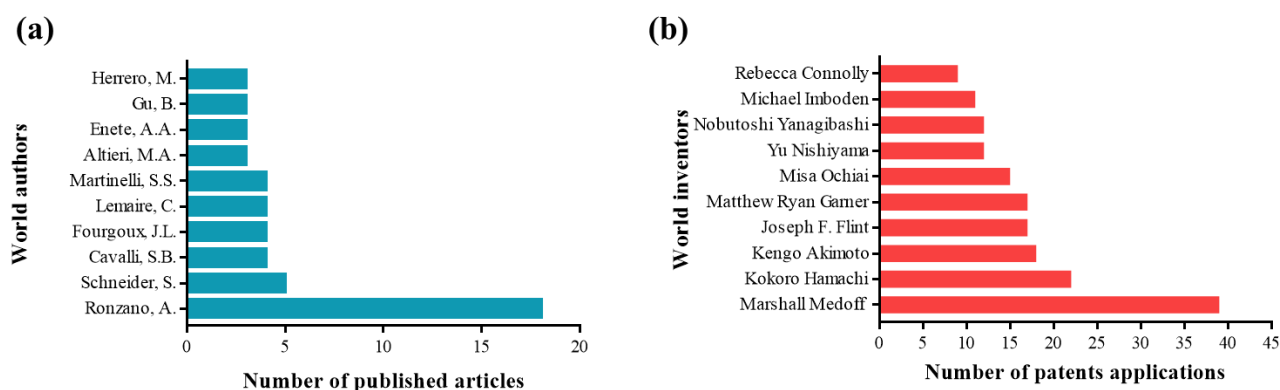


Figure 6. Distribution of the top 10 authors of published articles (a) and inventors of filed patents (b) related to the participation of family farming in the development of new food products.

Sergio Schneider is the author with the second-most publications and is affiliated with the Federal University of Rio Grande do Sul. In some of the publications by this author, Suzi Barletto Cavalli and Suellen Secchi Martinelli are credited as authors, who are both affiliated with the Federal University of Santa Catarina. One of these articles is “Family farming in times of COVID-19”, which sought to discuss the effects of COVID-19’s containment measures on family farming food production and distribution, and strategies that could be used to strengthen the sector [59]. Notably, this is an important study to help valorize the family farming sector [59].

Cavalli and Martinelli determined the effects of using food products from family farming on school menus in southern Brazil. Based on their findings, adding food products from family farming to the school menu improved the variety of fresh and natural products [59]. Both the authors published four articles that were present in the search. Many studies have been carried out in Brazil on the subject, which may be due to the country’s leading role in the production of scientific articles related to family farming in Latin America (Figure 5a).

Miguel Angel Altieri, who is affiliated with the Centro Latinoamericano de Investigaciones Agroecológicas and has three publications on the topic, published an article on the development of agricultural systems for small farmers [60]. According to the article, although the small farms lack large land or sophisticated equipment, these farms can be quite productive, and their productivity could increase with the help of agricultural systems [60].

Of the 10 main authors, Jean Louis Fourgoux affiliated with the French company Fourgoux-Djavadi & Associés, Anselm Anibueze Enete affiliated with the University of Nigeria, Baojing Gu associated with the College of Environmental and Resource Sciences of China, and Mario Herrero affiliated with the Commonwealth Scientific and Industrial Research Organization of Australia were authors of articles that were not exclusively related

to family farming. These publications were generally on the impact of farm size on food production [61,62].

Regarding the number of patents per inventor, after a brief analysis, the top 10 inventors with the highest number of inventions, as shown in Figure 6b, mainly filed their patent applications through companies based in the US and Japan. For example, Marshall Medoff contributed the most patents by filing 39 patent applications through the US company Xyleco and as an independent inventor.

All inventions of Marshall Medoff are related to biomass processing. In patent US20100124583, entitled Biomass Processing, the author reports that raw materials can be used in animal feed [62]. Another invention is related to biomass processing and its composition; these inventions can benefit agriculture in the future [63].

The second-largest inventor, Kokoro Hamachi, filed 22 patent applications through the Japan-based company Sekisui Chemical Co. Ltd. The inventors Nobutoshi Yanagibashi and Yu Nishiyama, filed patent applications alongside Hamachi. Their inventions are related to the chemical field, with patents JP2021004189 and JP2021004191 highlighting this relationship; these patents aim to protect an ethanol comprising specific organic components [64,65]. There has been increasing awareness of environmental issues in recent years and of the study of edible raw materials, such as corn. However, according to Hamachi, these raw materials cause an increase in food prices as the agricultural land area is used to produce different types of food, which is problematic, as it can affect the consumer [66]. Hamachi's invention can solve this problem by considering non-edible raw materials, which could help small-scale farming [66].

The inventor, Kengo Akimoto, filed 18 patent applications through a Japanese company, Suntory Holdings Ltd., and filed other patent applications with other independent inventors. One of the patents is a method for producing oil containing polyunsaturated fatty acids, which can be incorporated into agricultural products that can benefit family farming, such as animal feed and food or pharmaceutical compositions [67].

The inventors, Joseph F. Flint and Matthew Ryan Garner, filed approximately 17 patent applications through the US-based company, Microbios Inc. Their invention was regarding Lactobacillus-based probiotic compositions for inclusion in microbial-based products. These products can be used as additives for animal feed, as stated in the patent, US10864237 [68]. These inventions could be used in the future by small-scale farmers. As these top ten inventors filed with US and Japanese companies, this reflects the growing dominance of these countries in patent filings. According to the WIPO, the US and Japan were the top filing countries in 2020, along with China [69].

The inventor Michael Imboden filed 11 patent applications through the US company, Iogenetics LLC. The invention of this author is related to specific biocides. The mechanization of family farming presents some inconveniences, such as in food processing operations, with bacterial and fungal contamination that consequently leads to damage [70]. Therefore, this specific biocide could be an approach to neutralize these microorganisms and improve cultivation for family farmers [70].

Rebecca Connolly is the inventor with the tenth-most inventions, with approximately nine patent documents filed through the company SureHarvest based in the USA. Her inventions are related to the collection and provision of data on agricultural products and their practices to consumers, regulatory agencies, handlers; this is because consumers are becoming more concerned with the nature of food [71]. Therefore, this invention aims to create a system to track and report the environmental impacts and information on the agricultural producer, which can help family farmers with this information [71].

3.8. Article Financiers and Patent Document Depositors

To start a research project and subsequently publish the results in a journal in order to expand the knowledge on the subject, a funder is needed. This is because some publications may have financial charges, so funders that can be Universities/Research Institutes or companies can assist in this step. Similarly, it is interesting to identify the distribution of patent document

deposits that can be filed by Universities/Research Institutes, companies or independent depositors. Therefore, it is important to identify who are the main funders of the articles and patent applicants to have a dimension of who invests most in this technology.

As shown in Figure 7a, the distribution of funders for articles published on the participation of family farming in the development of food products is 17% for companies and 83% for research institutions, including Wageningen University (Wageningen University & Research), UFSC (Federal University of Santa Catarina), Michigan State University, Chinese Academy of Sciences, and UBC (University of British Columbia), who are the main providers of the funding for the published articles (Figure 7b).

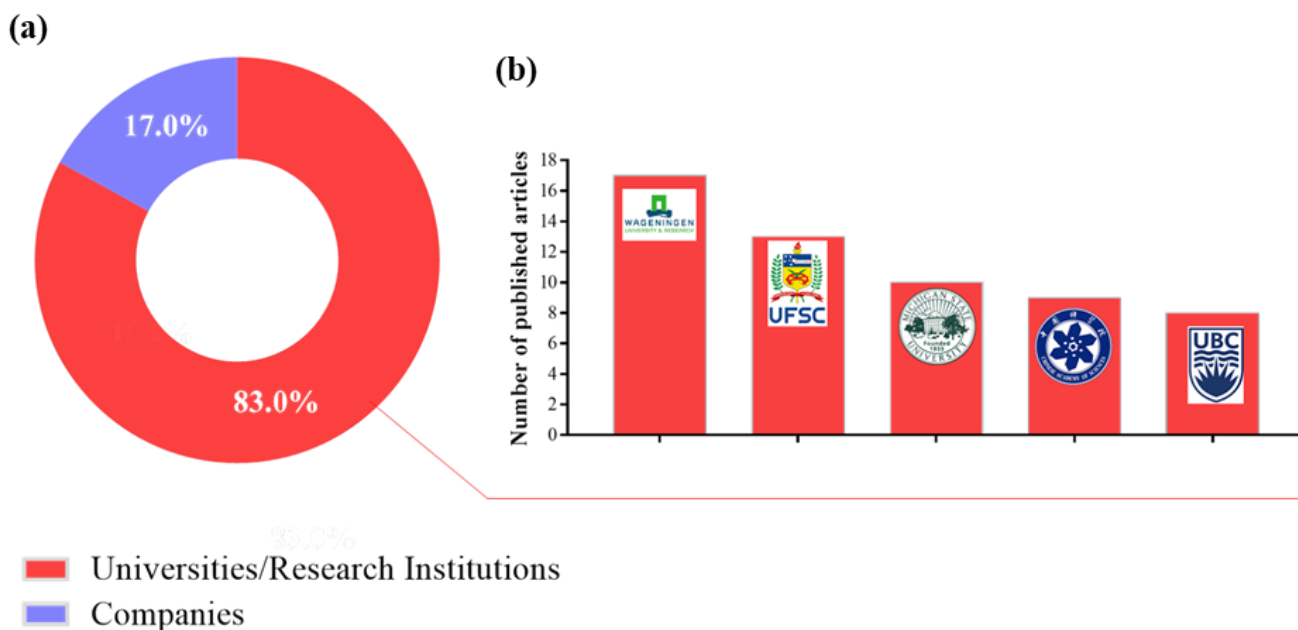


Figure 7. Distribution of the funders for articles published on the participation of family farming in the development of new food products (a) and the top 5 Universities/Research Institutions that provided the financial support for the published articles (b).

This result reflects the large amount of funding that universities and research institutes receive in developed countries, either through public resources, with transfers from the government of each country or private resources with donations and monthly fees. A recent article revealed that approximately 36% of the source of revenue is obtained from research funding (public or private) from the highest ranked universities in the world [72]. Public funding plays an important role through research grants or laboratories maintained by the governments [72].

In Brazil, there are partnerships between public institutions and the private sector that encourage companies to face international competitiveness. In some cases, the university provides the funding, and the results are incorporated into the private sector, which returns the investment to the government [73]. As the UFSC ranks second in the number of publications of articles related to family farming, this is proof of such partnership (Figure 7b).

Based on the general distribution of patent applicants in the participation of family farming and the development of food products, most are companies (52%), followed by independent depositors (37.3%) and universities and educational institutions (10.7%), as shown in Figure 8.

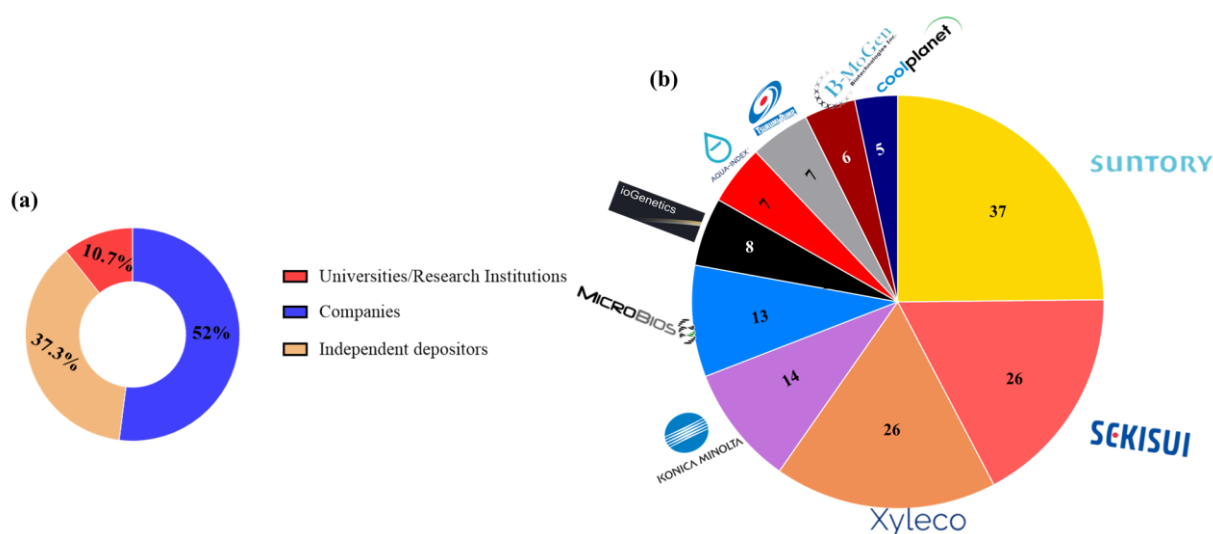


Figure 8. Distribution of patent applicants regarding the participation of family farming in the development of new food products (a) and top 10 companies that filed patent applications on the subject (b).

Companies are at the forefront of patent filing as innovation increases their growth and adds to their value [74]. Accordingly, companies that follow this path usually have great growth indicators [74]. In addition, in some countries, companies join universities to allow researchers to carry out innovative assessments [74].

Notably, the top 10 companies that filed patent applications were located in developed countries, such as Japan and the USA (Figure 8b). Among them were companies related to the development of new products, such as Suntory, which produces drinks, especially alcoholic beverages [75]. Sekisui produces plastics, drinks, paints, and resins and presents advances in the application of microorganisms and enzymes in the manufacture of alcoholic beverages [75]. Xyleco allows for the development of processes for the conversion of biomass into useful products and inexpensive products for housing, clothing, food, medicine, energy, materials, and other necessary items [76]. Konica minolta works with the most diverse technologies and always pushes the development of new products [77]. Microbios specializes in the research and development of microbial technologies to promote human and animal health and healthy agricultural production ioGenetics seeks to develop antimicrobial proteins [78].

The number of independent depositors filing patent applications is markedly increasing. Accordingly, universities and research institutions are contributing a lower percentage, which can be an alternative for inventors from countries that do not have large investments in science and technology. For example, despite the existence of laws to encourage technology, Brazil allocates very little of its gross domestic product (GDP) to encourage research; this situation is the same for other Latin countries [79]. However, this low investment reflects economic indicators; therefore, developed countries have minimal chances of facing economic problems [79]. Further, despite the economic crises faced in the past, countries, such as Japan and the USA, have not reduced their investments in the science and technology sector, allocating approximately 3% to 2% of their GDP [79].

4. Conclusions

From the studies found, it can be concluded that the articles bring an overview of the participation of family farming in the development of food products, whether in the product itself or in the elaboration process, dealing mainly with the sale, marketing and impact of products developed by family farmers on society in general, evaluating their acceptability and identifying possible strategies that assist in the introduction of these products on the market. The patent documents found were for food products related to family farming, most of which were registered in the subgroups of food products for ruminants and their mode

of production, as well as in the agricultural application for the development of innovative technologies for production, including machines and forms of production, the most common application area being “agriculture and biological sciences”. Among the main innovations developed by family farming is the manufacture of food products such as biscuits, cereal bars, flour, jams, yogurts and ice cream made from raw materials grown by these families. Therefore, the scientific and technological perspectives show the great potential of family farming foods, as the food industry has proven to be the largest technological holder in family farming, as both articles and patents filed are mainly related to the development of innovative products from raw materials produced in family farming.

Author Contributions: V.d.L.S.—original draft preparation, conceptualization, methodology and editing, F.d.E.S.d.J.—original draft preparation, conceptualization, methodology and editing, E.C.M.—original draft preparation, conceptualization, methodology and editing, J.S.d.L.—original draft preparation, conceptualization, methodology and editing, L.Q.d.M.M.—editing, T.S.O.—editing, E.F.d.S.—editing, I.L.N.—editing, B.A.S.M.—editing, S.S.C.—editing and C.D.F.R.—editing. All authors have read and agreed to the published version of the manuscript.

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