Blockchain Technology Applied To The Food Supply Chain: Systematic Literature Review

Cruzalegui, Robert J[1]*; Cruz, Rosita[1]; Auquiñivin – Silva, Erick A[1]; Luque – Chuquija, Euclides W[2]; Maldonado – Ramírez Italo[3]

1. Instituto de Investigación, Innovación y Desarrollo para el Sector Agrario y Agroindustrial (IIDAA), Facultad de Ingeniería y Ciencias Agrarias, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Calle Higos Urco 342-350-356, Chachapoyas 01001, Amazonas, Perú
2. Facultad de Derecho y Ciencias Políticas, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Calle Higos Urco 342-350-356, Chachapoyas 01001, Amazonas, Perú
3. Facultad de Ingeniería de Sistemas y Mecánica Eléctrica, Universidad Nacional Toribio Rodríguez de Mendoza de Amazonas, Jirón Libertad 1300, Bagua 01721, Amazonas, Perú

*robert.cruzalegui@untrm.edu.pe

Abstract

The purpose of the study was to identify the factors in the application of blockchain technology in the food supply chain based on a bibliometric review of academic and professional papers obtained from the indexed database Scopus using analysis tools to visualize and build bibliometric networks. The results allowed identifying traceability, internet of things and trust as factors that influence the application of blockchain technology in the food supply chain ensuring competitiveness and sustainable development in medium, small and large companies. In addition, 50% of the analyzed articles on Blockchain in the food sector focus on the regions of India, China, Italy and the United Kingdom. Recommending the application of this technology in non-traditional agricultural products due to its reliability.

Keywords: Blockchain technology, supply chain, traceability, Internet of Things.

INTRODUCTION

Food is the source of nutrients and natural bioactive compounds required by man to live a healthy life and that come mostly from the agricultural sector, whose production on a commercial scale generates increased income in developing countries worldwide. Technologies in the agricultural sector for food production have a direct relationship with the increase of its competitiveness and sustainable development, but their adoption by producers is limited due to the existing discrepancies between the scientific research developed and the needs of the food supply chain (Contreras-Medina et al., 2020; Sharma et al., 2020).

There are tools and technologies that aim to increase competitiveness and sustainable development in the food supply chain, from the acquisition of strategic inputs to the final consumer, and that also take into consideration the sustainable development goals of the United Nations in its attempts to reduce chronic child malnutrition worldwide (Kittichotsatsawat et al., 2021; Tsolakis et al., 2021).

Figure 1, shows a systematization of research referred to the application of Blockchain in the food supply chain from 2017 to the present, revealing an increase in interest in its study exponentially, as it is a decentralized innovation tool that ensures increased competitiveness and sustainable development in the food supply chain from the agricultural sector (González-Puetate et al., 2022).

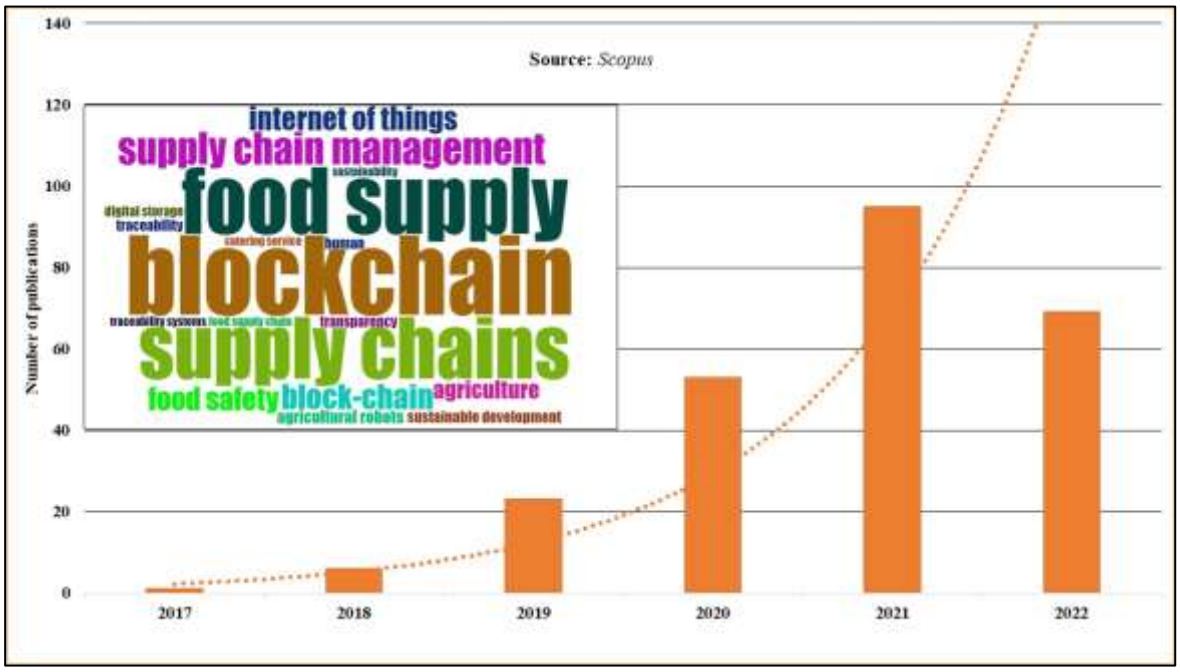

Figure 1. Blockchain technology research applied to food

Blockchain technology, is a digital and encrypted tamper-proof tool allowing supply chain participants to trust and interact securely and is not owned by decision of any of the participants (Thiruchelvam et al., 2018). Recently, this technology is generating interest in academia and practitioners, however; little is known about its impact and benefits in the food chain.

Traditional supply chains apply centralized management systems where there are risks of piracy and corruption, as is the case of planning systems, oriented to manage resources necessary for its normal operation of a company (Paul et al., 2021). So, these limitations can be given solutions using blockchain technology, also called blockchain.

In this context, through the systematic review it is important to answer the research question we have proposed: how does blockchain technology influence factors in the food supply chain? Therefore, the objective of this research is to identify the main factors that influence blockchain technology as a tool in the food supply chain from a systematic review of academic and professional papers obtained from the indexed database Scopus in recent years in order to answer our research question.

METHODOLOGY

A systematic review was performed both academic and professional of the indexed database Scopus with the following search criteria: ARTICLE TITLE, ABSTRACT, KEYWORDS "food, supply, chain" AND KEYWORDS "blockchain", these criteria were combined differently having as a result of this review 247 records between original and review articles, with the aim of answering the research question How does blockchain technology influence the factors of the food supply chain?

For the analysis of the reality once the studies were selected, we proceeded to summarize and evaluate the differences of each study, identifying the quality of the available evidence for obtaining figures and tables that synthesize the evidence (Linares-Espinós et al., 2018). In addition, analysis tools were used to build and visualize open-access bibliometric networks, which allowed building a transdisciplinary understanding of blockchain technology in the transformation of the food supply chain, performing an integrated and systematic review of both (Wang et al., 2018).

Finally, for the systematization of the articles obtained, we selected works published from 2017 to the present, developing the subject matter by sections; starting with the fundamentals of blockchain technology, food supply chain, food traceability and finally an analysis of the internet of things; according to the highest incidence of the factors resulting from the literature search presented in Figure 2 that guarantee to answer our research question.

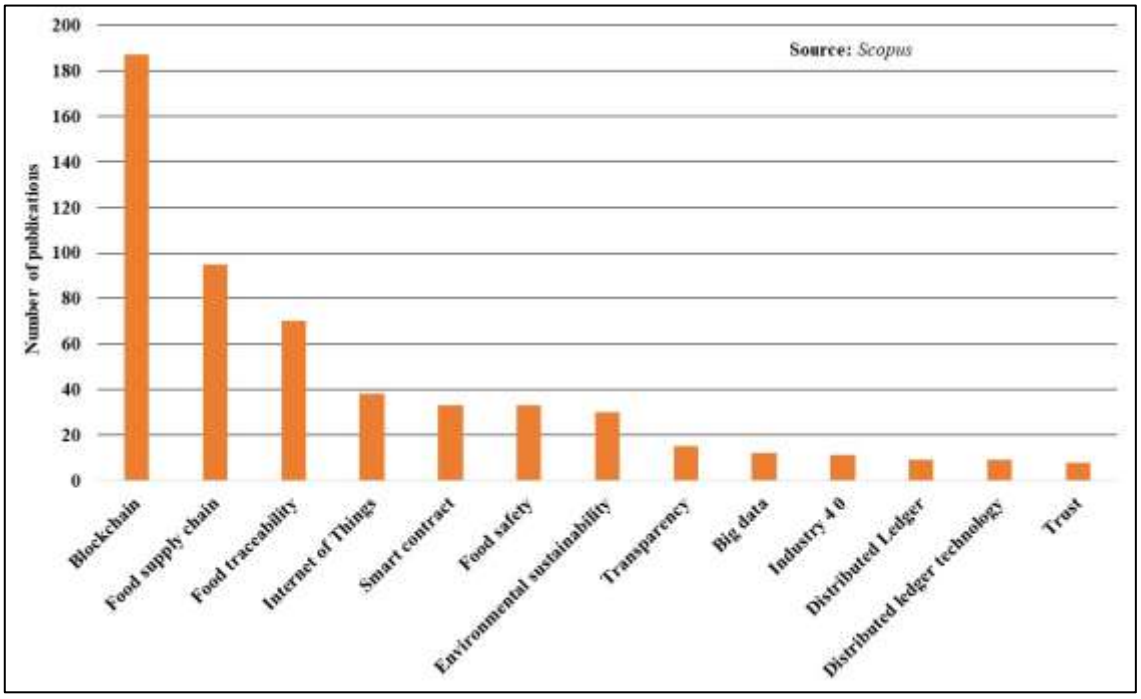

Figure 2. Investigations of blockchain technology applied to food.

RESULTS AND DISCUSSIONS

Fundamentals of blockchain technology

The blockchain technology had its beginnings in 2008 due to the rapid growth of a core component of the cryptocurrency Bitcoin, where financial services were the starting point of this technology (Bhardwaj and Kaushik, 2018; Galvez et al., 2018). The blockchain is a distributed database in various records, or also called an accounting ledger where various digital transactions executed by blockchain participants are recorded (Crosby et al., 2016; Dutta et al., 2020).

Blockchain technology through the digitization of processes improves the efficiency and effectiveness of the food supply chain, increasing general capabilities such as information exchange, coordination and transparency among those involved in the supply chain (Lambourdiere and Corbin, 2020). Other capabilities provided by the blockchain through its implementation are transparency, visibility, traceability; integration, operationalization, disintermediation and

decentralization; in addition to fostering smart contracts and consensus mechanisms (Kayikci et al., 2021).

Table 1, shows recent research that has as its central objective to show applications of blockchain technology and its influence on the supply chain of fresh and processed foods, also acknowledging that this technology is ideal because it combats imitations, generates positive effects on profits by decreasing the number of operations using less human resources in the supply chain, also benefiting the company in the protection of counterfeiting of its brand and eco-labeling (Balzarova, 2020; Martinez et al., 2019; Shen et al., 2022).

Finally, Blockchain generates functional, economic, environmental; social and technological impact generating integrity in the food supply chain process; likewise, it is a disruptive technology emerging from the fourth industrial revolution 4.0 (Erol et al., 2022; Kumar et al., 2022; Lezoche et al., 2020). Therefore, it is concluded that this technology is applicable to medium, small and large companies, due to its low implementation cost and confidence in data management at the organizational level.

Table 1. Application of blockchain technology in food

Food	Objectives	Source
White sugar	Propose the design of an integrated agribusiness supply chain system for crystal white sugar based on blockchain	(Ekawati et al., 2021)
Cocoa	Develop a framework of hierarchical enablers in improving transparency in the sustainable supply chain in the cocoa industry.	(Bai et al., 2022)
	Blockchain for resilience and sustainability of the post-covid-19 cocoa supply chain to connect buyers directly with smallholder farmers.	(Quayson et al., 2020)
Coffee	Support ethical trade by implementing digital traceability technologies in supply chains to provide consumers and producers with enhanced product-specific information.	(Chopra and Kundu, 2008)
Honey	To build and use worldwide an open, image-based traceability system designed for sustainable development.	(Rünzel et al., 2021)

Mango	Explore to unravel the interactions between different management activities that have an effect on quality variability in mangoes.	(Zúñiga-Arias et al., 2009)
Fine wines	Present a method to eliminate product counterfeiting, taking harvesting as a starting point, using smart contracts and blockchain tokens.	(Dos Santos et al., 2021)
Fresh milk	Mapping milk supply chains to explore the flow of information between different members for greater traceability and investigating the social impacts of blockchain technology.	(Mangla et al., 2021)
Olive oil	To guarantee the veracity of the product information at the different stages of its production.	(Alkhudary et al., 2022)
Tea	Analyze a structural equation modeling method based on partial least squares regression with data collected from experts.	(Paul et al., 2021)
Hemp	Model a user-focused design through the implementation of blockchain and the internet of things to ensure tamper-proof, transparent and secure traceability.	(Ferrández-Pastor et al., 2022)
Pork	Formulate foreign supplier trade-offs between the cost of blockchain adoption, expanded market potential, and intensified competition with the local supplier.	(Niu et al., 2022)
Shrimp	Application of a hybrid public-private model for export based on blockchain from post-larvae purchase to the final packing stage.	(Akhtaruzzaman Khan et al., 2022)
Fisheries	To study the structure of food supply chains applying Blockchain that promote the fulfillment of development goals in the context of the Thai fishing industry.	(Tsolakis et al., 2021)
Fresh fruits	Analyze the obstacles facing the implementation of blockchain technology in fresh fruit preservation.	(Zhang et al., 2022)

Source: Scopus

Food supply chain

Blockchain technology has not long been implemented in the food industry (Figure 1), but in turn is gaining importance in the food supply chain, with traceability and trust being factors that dominate its adoption in agribusiness (Kamble et al., 2020; Wang et al., 2018). The application of blockchain as a technology in the food supply chain identifies four factors that facilitate supply chain management and three impede its normal operation; traceability being a central innovation of this technology while information dominance prevents it from

reaching its full potential and reduces its performance in the supply chain (Hald and Kinra, 2019).

This technology despite having very little time integrated with the supply chain management, in the electric power industry has a mature integration, followed by the pharmaceutical and transportation item demonstrated with the use of smart contracts (Queiroz el tal., 2019). In this context, blockchain technology provides transparency from suppliers to the final consumer; arousing interest to academics and entrepreneurs in other sectors with the aim of ensuring proper implementation (Gurtu and Johny, 2019).

Currently there are smart agricultural systems implemented (Table 1) that guarantee traceability and food safety, in addition, it eradicates adulteration and mislabeling of agricultural products, generating confidence from producers to final consumers; also this technology in the supply chain decreases the selling price of the product offered differentiation (Rünzel et al., 2021).

Blockchain, as a technology is applied to optimize the supply chain of international trade by simplifying the monitoring component, ensuring the integrity of the exchanged information (Juma et al., 2019). So Blockchain technology applied in the food supply chain is an opportunity to expand internationally by including new non-traditional agricultural products and has a potential in these markets.

Food Traceability

The food industry applies various technological tools to ensure good quality and safety in the supply chain, greatly minimizing potential bad publicity, liability and food recalls (Aung and Chang, 2014). Blockchain technology, a digital technology to achieve traceability and transparency in the agricultural food supply chain ensures food safety in various food groups (Madumidha et al., 2019).

Studies developed in recent years show that a digital traceability based on blockchain technology can have significant advantages in the food supply chain (Figure 3), also taking advantage of circular economy practices (Patelli et al., 2020; Sharma et al.,

2021). In this context, blockchain technology as a digital technology offers benefits in the management of the food supply chain, ensuring fast and reliable traceability that is easy to apply in medium, small and large companies; in addition to promoting fair trade, good agricultural and manufacturing practices that contribute to reducing administration and management costs (Baralla et al., 2021; Coello et al., 2021; Katsikouli, et al., 2021).

Traceability through the application of Blockchain technology is influenced by the applications of Industry 4.0, a sector influenced by automation, connectivity, digitalization and the efficient use of renewable energies that can be applied in monitoring, inspection and quality control, environmental control, precision agriculture, optimization of agricultural inputs, process automation, among others (Kumar et al., 2022). As mentioned above, there are barriers to implementing traceability in new agricultural products due to the lack of knowledge of the links in the production chain to be intervened that do not guarantee sustainability, but through the application of this technology could obtain results due to its reliability.

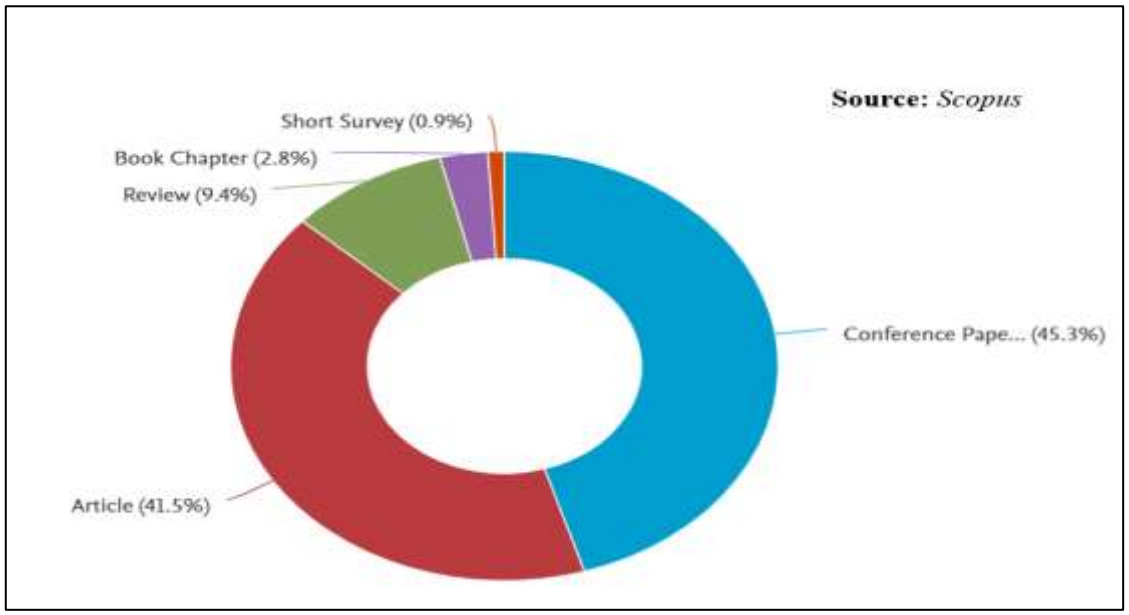

Figure 3. Types of documents analyzed

Internet of Things (IoT)

The internet of things has the potential to transform thoughts into information and communication technologies, in addition to being applied in disciplines such as communication, communication networks, business, security and management (Tseng et al., 2020). The internet of things as blockchain considered as distributed accounting technology are currently trending, although the former criticized for its limited security, while blockchain offers security in its implementation and operation (Liu et al., 2021).

Blockchain technology aims to provide anonymous transactions between participants, it also serves as a data provider in technology applications such as the internet of things (Florea, 2018). However, the internet of things as a technology, is also applied in the food supply chain, having as the beginning of such studies the year 2011; since then an increase is observed in peer-reviewed journal publications and since 2017 in the food supply chain (Figure 4), using sensors to obtain information regarding temperature, humidity and location of the agricultural product. (Bouzembrak et al., 2019).

Blockchain being a blockchain-based system, allows enabling new food production systems and electronic agriculture schemes that help strengthen the context of precision agriculture through the use of information and communications (Antonucci et al., 2019). In addition, the convergence of blockchain technology with artificial intelligence revolutionize smart city infrastructures to establish sustainable ecosystems for internet of things applications (Ahmed et al., 2022).

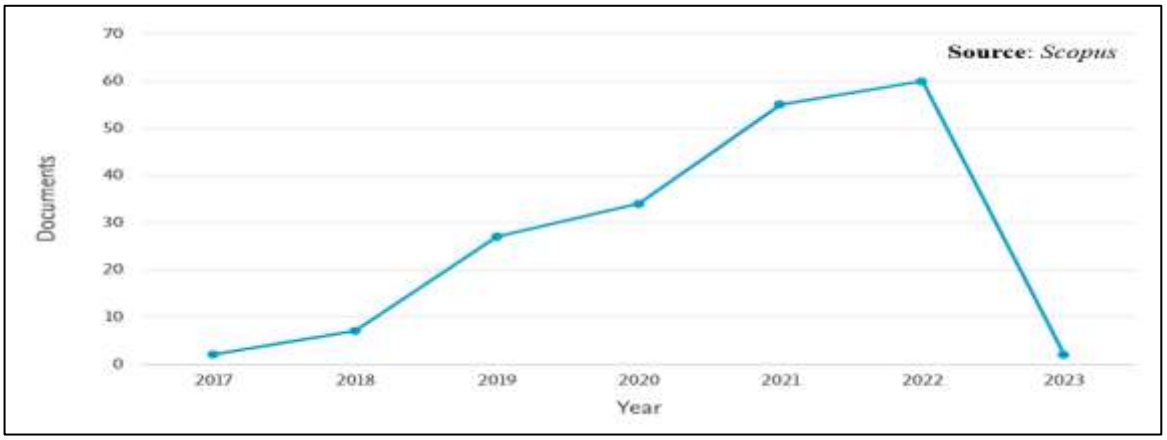

Figure 4. Types of documents analyzed by year

CURRENT AND FUTURE CHALLENGES

Blockchain technology in a conventional way has been widely applied and researched in activities in the financial sector from 2008 to the present, reporting exponential growth in applications in the food supply chain as of 2017 in the areas of computer science, engineering, business, management and accounting mainly (Figure 5). However, to date there have been no research or diverse studies that contribute to the study of non-traditional foods in the specific area of food engineering, in addition to patent reports, as well as business studies that can guarantee an economic, social and environmental sustainability of the productive chains immersed in the non-traditional food item.

The paper provides innovative and technological contributions for the future of blockchain technology, food engineering and food industry coming from the agricultural sector has been in constant as the development of precision agriculture, sensors, robots, various information systems for decision making are elements implemented throughout the process of transformation in agriculture and food in the world that every day becomes more demanding in terms of quantity and quality of products in the markets of the final consumer.

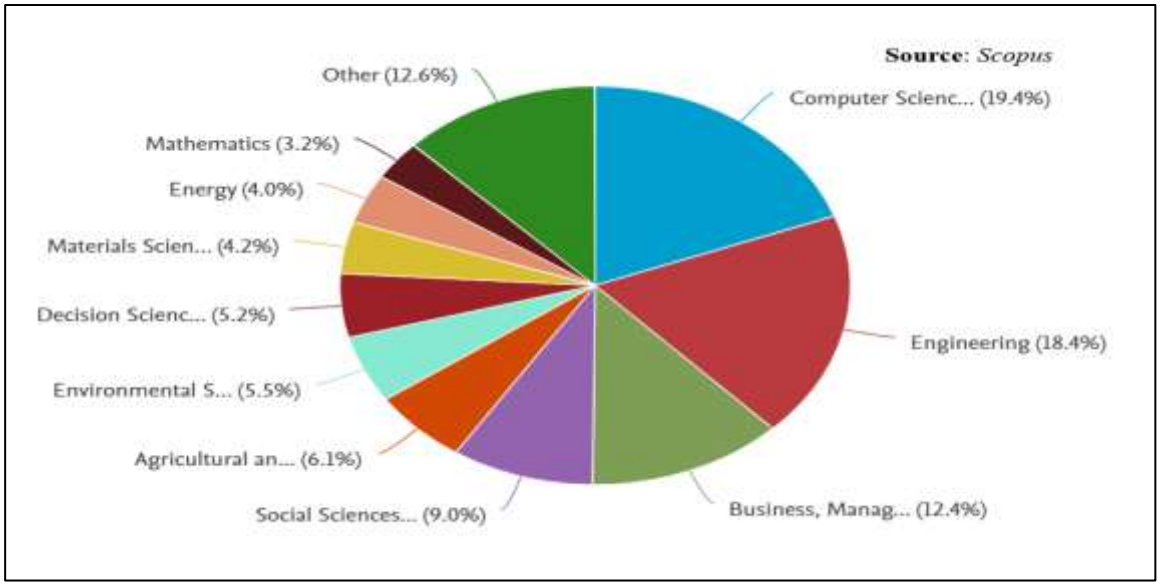

Figure 5. Documents by subject area

CONCLUSIONS

The food from agriculture industry is critical to feeding the world's population. Increasing population and competition for renewable and non-renewable natural resources poses a threat to the world's food security. This is why the use of disruptive technologies by the Blockchain is proposed to address these complex problems that are increasing in agricultural production systems.

Factors have been identified that relate disruptive information and communication technologies, including big data analytics, machine learning, , cloud computing and blockchain, can address problems, such as improving competitiveness, sustainability, water conservation, ensuring soil and plant health and improving environmental stewardship; but that do not guarantee traceability, security and trust for users; in the face of this Blockchain is a viable alternative for implementation in the food supply chain.

The food industry coming from the agricultural sector has been in constant scientific and technological innovation for decades. Innovations such as precision agriculture, sensors, robots, diverse information systems for decision making are factors that have been implemented in the whole process of technological transformation in agriculture and food in the world.

The results show that 50% of the analyzed articles on Blockchain in the food sector are focused on the regions of India, China, Italy and the United Kingdom; with a higher concentration of research in the Asian and European community (Figure 6). This is due to the presence of large companies involved in food production and marketing around the world.

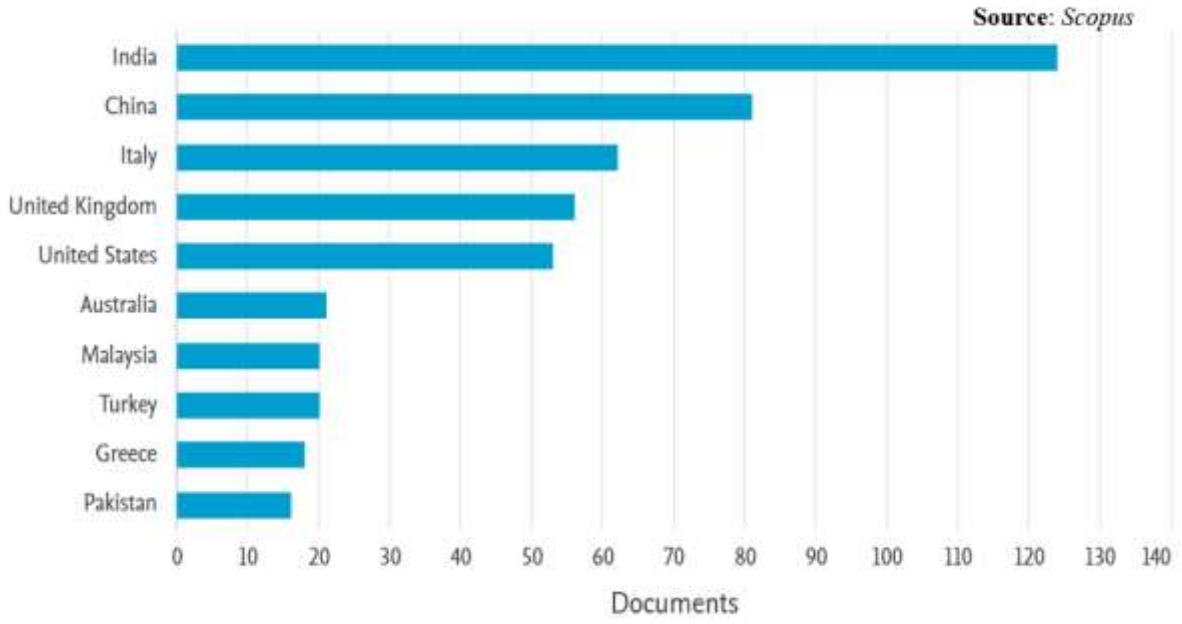

Figure 6. Scientific production by main countries

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