Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 6, 2021, Pages. 9163 - 9168
Received 25 April 2021; Accepted 08 May 2021.

Technological Development and Scientific Production in Biotechnology in Latin America

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Abstract. Biotechnology has aroused the interest of social actors because of its potential impact on the development of countries as a base technology applicable to various productive activities. The present paper describes and relates, for Latin America, regarding Biotechnology (during the period 2010 to 2018) the production of knowledge and its use, measured in scientific articles and citations, with the technological development, taking into consideration the granted patents. Only Mexico, Brazil and Cuba report patent grants in this region. Regarding scientific production, 49% correspond to Brazil, followed by Mexico (18%) and Argentina (11%). Citations dropped significantly, reaching only 5% of what was observed in 2013.Additionally, it was found that there is a very high correlation between scientific production and patents granted in Biotechnology.
Keywords:patents, scientific publications, Latin America, biotechnology, innovation.

1 Introduction

In 1982, with the amendment of the U.S. Patent Act, patenting procedures were facilitated by universities and public institutes, promoting research and development in the so-called new technologies. Among these new technologies is modern biotechnology, which is made up of a set of scientific and technical principles applicable to specific developments[1].The Organization for Economic Cooperation and Development (OECD) defines it as the scientific and technological application to living organisms, their parts, products and models intended to modify living organisms and/or materials for the production of knowledge, goods and services. Its main applications are in the livestock, plant genetics, pharmaceutical and food industries [2].

Biotechnology has served as a basis for the development of specific technologies in productive activities with the application of science and engineering at the industrial level (scientific or productive), innovatively combining biology and process engineering to promote the welfare of humanity [3]. In this way, it has a favorable impact on the development of countries, becoming a capital goods industry of the knowledge society, thus offering new spaces for public-private exchange at the scientific, technological, and productive levels [1].

Research in this sector has increased thanks to the promotion of links between research centers, through international collaboration provided by more developed countries in biotechnology research, such as the United States, Japan, Germany, England, Spain and France [4].Thus, the production of knowledge in Biotechnology, measured in scientific publications, doubled worldwide between 2000 and 2008, representing 4% of the total scientific production registered in the *Science Citation Index* in the same period [5].

On the other hand, the relationship between publications and patents in Biotechnology has been the subject of studies [6] where publishing activity, the impact of citations and the links of citations between publications and patents in biotechnology have been analyzed.In the case of countries in the Latin American region, the United Nations Economic Commission for Latin America and the Caribbean (CEPAL) [1] has studied the scientific and technological

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level of advances in biology, fine chemistry, plant breeding, bovine genetics and similar, within the framework of the previous model of endogenous technology generation; in addition to institutions and operating routines as basic elements to promote their own developments.

The effects of modern biotechnology on the development of Latin American countries have also been analyzed, based on public efforts and incipient private developments, reviewing the possibilities and limitations that these technologies pose for the countries of the region [1]. In the same vein, the relationship between innovation and the competitiveness, economic and social development of a country has been analyzed[7] [8].

Likewise, in Latin America, Ronda Pupo et al [4], studied the research carried out in Biotechnology by combining social network analysis techniques with bibliometric methods, in the period 1988 and 2012. As a result, they found a positive correlation with the intermediation of the countries, demonstrating the importance of international collaborative networks as a way to develop research on biotechnology in this region. This stands out when observing a growth of 12 times the scientific production in this area in 2010 with respect to 1990, being Brazil, Argentina, Mexico and Chile the countries with greater scientific production in this area of research.Likewise, Cuban science and technology have been recognized for important achievements, particularly in human health and biotechnology [9].

This increase in publications in Biotechnology found by Ronda Pupo et al in Latin America, in the period 1988 and 2012, has not been maintained in the region for the period 2013 to 2019 where, according to data published in Scimago in the annual reports Scimago Journal & Country Rank (SJR) [10], only a 33% increase in publications is appreciated. This is observed together with a 94% decrease in the citations of said papers, which responds to the general situation presented by Latin America in publications during that period, with an alarming 93% decrease in citations. Even so, it is worth asking whether this modest growth in scientific publications in Biotechnology has any association with the patents granted in Biotechnology.

The present paper aims to describe quantitatively the behavior of research and technological development in Biotechnology in Latin America during the period 2013 to 2019. This paper will be carried out through the analysis of bibliometric indicators reported by Scimago Journal and Countries Ranking (SJR) [10] regarding publications and citations in this area, as well as figures on granted patents, published by World Intellectual Property Organization(WIPO) [11].

2 Methodology

For the descriptive analysis of the performance of research and technological development in Biotechnology in Latin America during the period 2013 to 2019, descriptive statistics are applied to the bibliometric indicators reported by the Scimago Journal and Countries Ranking (SJR) [10] with respect to publications and citations in this area. Likewise, figures on granted patents published by the World Intellectual Property Organization (WIPO) [11] in the above-mentioned period are analyzed.

For the purpose of the results, firstly, the analysis of the Scientific publications and citations are presented, secondly, the patents granted in Biotechnology, and finally, the relationship between the publications and patents.

3 Results

3.1 Scientific publications and citations in Biotechnology

The publication of scientific articles in Latin America in Biotechnology during the period 2013 to 2019 has presented a modest growth of 33%. Brazil accounts for 50% of these

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publications (Table 1), followed by Mexico (18%) and Argentina (11%). On the other hand, important increases in the production of knowledge in this sector are observed, mainly by Chile and Mexico; unlike Colombia and Cuba that show decreases in the amount of their publications.Another aspect that stands out is the marked decrease of 96% of the citations received in this sector by the end of this period (Table 1, Fig.1).

Table1. Publications in Biotechnology by country and year, 2013 to 2019.

Country	2013	2014	2015	2016	2017	2018	2019	Total	%total	%Increase
Brazil	868	791	864	931	947	1026	1127	6554	49%	30%
Mexico	286	280	292	333	383	408	479	2461	18%	68%
Argentina	221	202	173	215	228	238	226	1503	11%	2%
Chile	92	116	107	125	116	118	160	834	6%	74%
Colombia	120	108	139	243	97	102	107	916	7%	-11%
Cuba	68	58	40	33	25	27	32	283	2%	-53%
OthersCountries	81	89	129	153	114	152	178	896	7%	120%
LatAM	1736	1644	1744	2033	1910	2071	2309	13447	100%	33%
CitationsLaTAM (thousands)	28.6	24.8	23.1	19.3	12.4	7.3	1.6	117.3		-94%
Citations Per Document	16,5	15,1	13,2	9,5	6,5	3,5	0,7			-96%

Source: Scimago SJCR [10]

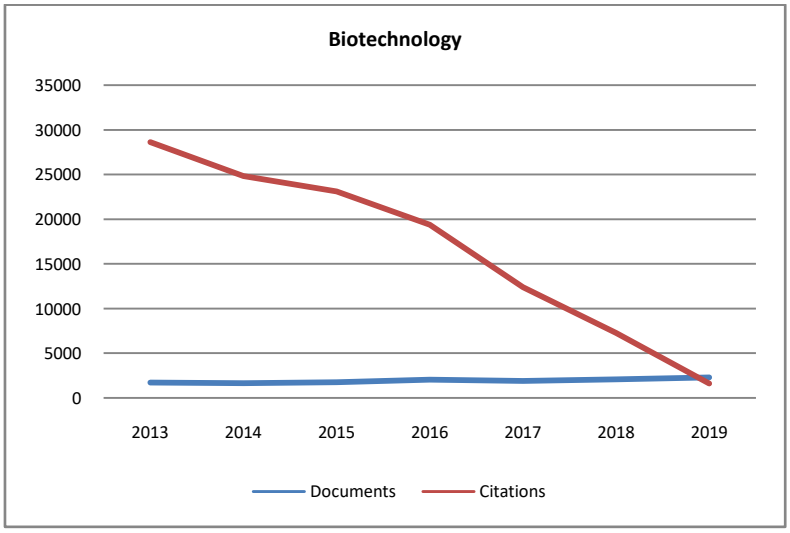

Fig. 1.Scientific publications and citations in Biotechnology in Latin America, period 2013-2019.Elaborated from data published by Scimago in SJR [x].

3.2 Patents granted in Biotechnology in Latin America

According to what is reported by WIPO, there are three (3) Latin American countries that present patents granted in Biotechnology, namely Cuba, Brazil and Mexico.Until the year 2015 (Fig.2), it is observed that the region barely reached a hundred patents, processed mainly by Brazil.

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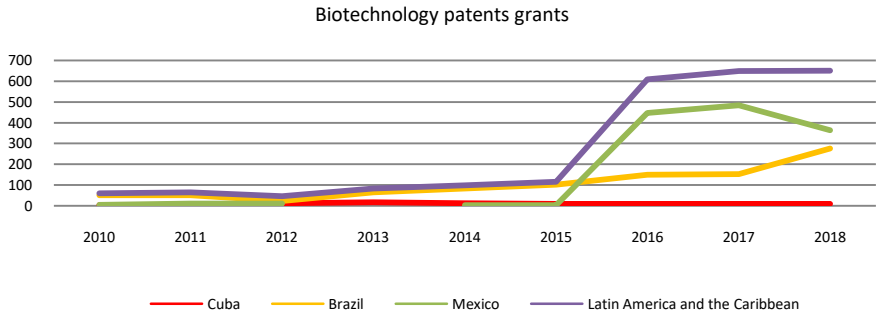

Fig. 2.Patents granted in Biotechnology in Latin America, period 2010 to 2018. Elaborated from data published by WIPO [x].

Table 2. Total publications in Biotechnology by country (2010-2018).

Country	Total	%	%Increase
Cuba	84	4%	300%
Brazil	962	41%	533%
Mexico	1328	55%	7280%
Total	2374	100%	1083%

As of 2016, Mexico will quadruple this Latin American figure, surpassing Brazil by far. Nevertheless, the sustained growth of the latter, and the decline of Mexico, shows a trend to approach by 2018. In the case of Cuba, since 2015, nine granted patents have been presented per year, representing 4% of the Latin American total. Mexico leads the total number of patents granted during the 2013-2018 period with 55%, followed by Brazil with 41% (Table 2).

3.3 Relationship between publications and patents granted in Biotechnology in Latin America.

Regarding the correlations, a very high association (0.93) is observed between the granted patents and the documents published and indexed in Scopus during the period 2013 to 2018 for the Latin American region (Fig.3 Table 3). By country, high correlations were also observed. Considering the scientific publications, Brazil is the Latin American leader, tripling the figures of Mexico. Regarding patents, although Mexico made important efforts to increase its figures as of 2015, this has not been maintained for the following years. Thus, by 2018, the gap with Brazil will be 24%, with a tendency to reduce this gap.

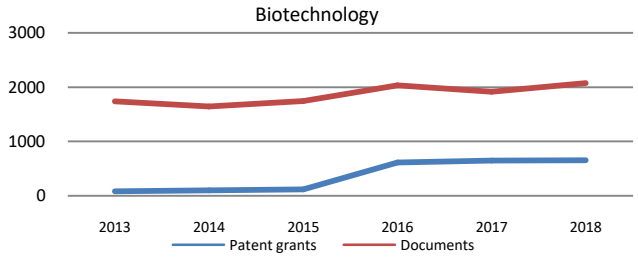

Fig. 3.Patents granted and publications in Biotechnology in Latin America, period 2013 to 2018. Own elaboration.

Table3. Correlation by country and region, between scientific production and patents granted in Biotechnology (2013-2018).

Country	Pearson

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	Correlation
Cuba	0,91
Mexico	0,81
Brazil	0,91
Latam	0,93

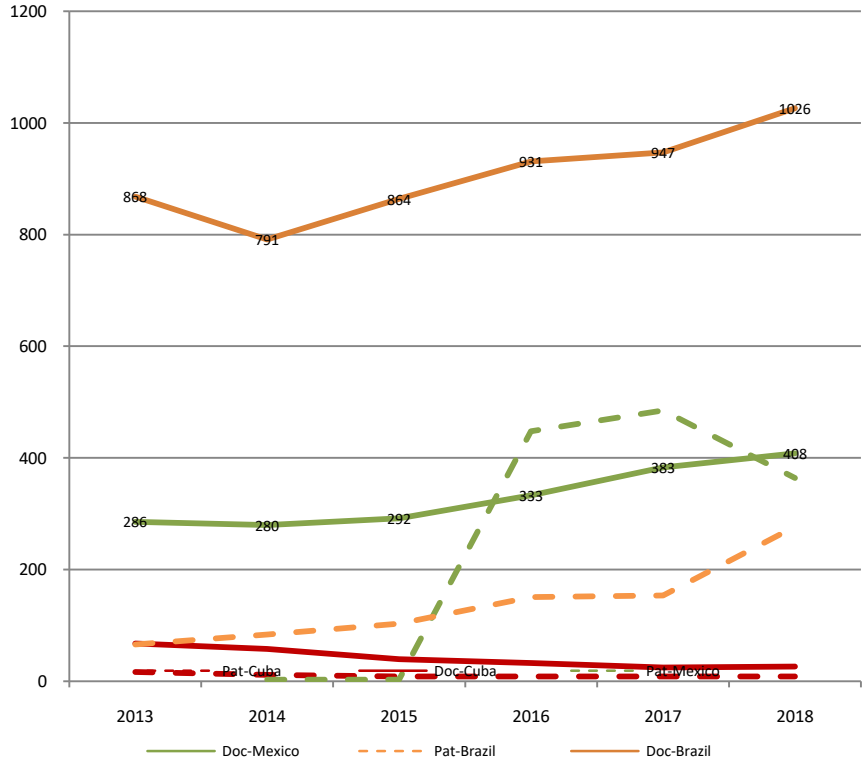

Fig. 4.By country, patents granted and publications in Biotechnology in Latin America, period 2013 to 2018. Own elaboration.

4 Conclusions

The production of knowledge, measured in publications, as well as the technological application in granted patents, have been analyzed for Latin America for the period 2010 to 2018. It is found that only Mexico (55%), Brazil (41%) and Cuba (4%) reported patent grants in this region. Regarding scientific production, Brazil generated 49% of this area, followed by Mexico (18%) and Argentina (11%), the increase in the region being 33%.Citations dropped significantly, reaching only 5% of what was observed in 2013.

As for the relationship between scientific production and granted patents, it is found that there is a high correlation between them.

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