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VITICULTURE AND ENOLOGY

RESEARCH NOTE

Scientific productivity and collaboration in viticulture and enology in Latin American countries

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Abstract

J.L. Aleixandre, E. Bordeu, J.L. Aleixandre-Tudó, M. Bolaños, and R. Aleixandre-Benavent. 2013. Scientific productivity and collaboration in viticulture and enology in Latin American countries. Cien. Inv. Agr. 40(2): 429-443. The aim of this study was to analyze the scientific activity of Latin American researchers in viticulture and oenology through bibliometric analyses of articles included in the Science Citation Index Expanded database for the period of 2006 to 2010. A total of 917 research articles were published in 364 domestic and international journals. We highlight the important growth in the number of research papers published during the period, especially in Brazil, Argentina and Chile, as well as an increasing number of international collaborations, mainly with non-American grape- and-wine producing countries. A social network analysis of collaborations between institutions and countries was also performed. The combined analysis of productivity, collaboration and scientific impact provides a global and integrated vision of the research conducted in this area in Latin America.

Key words: Impact factor, Latin American countries, network analysis, scientific collaboration, scientific productivity, viticulture and enology.

Introduction

Four countries, Argentina, Chile, Uruguay and Brazil, are the major producers of wine and have the largest areas under grape cultivation in Latin America. The wine regions are located in temperate climates on the slopes of mountains and valleys. Good soil and climatic conditions have made it possible for nearly 3,000 growers to cultivate over 500,000 hectares of vineyards in the region.

There are nearly 700 wineries that utilize approximately 70% of the total production of grapes in Latin America (Aleixandre and Crespo, 2005).

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While production has traditionally been dominated by red wines, there is now a tendency towards a balance between white and red wines and an increasing amount of distillates and table grapes. There is also a growing interest in the treatment of waste water produced by the expanding wine industry (Gonzalez *et al*. 2003; Oliver *et al*. 2006).

Some countries in Latin America hold much prestige within the group of New World wine-making countries. In particular, Argentina, Chile, Brazil and Uruguay produce 90% of the wines in the area, a total production of approximately 30 million hectoliters, and are the 5th, 10th, 15th and 20th highest ranked producers in the world, respectively. They export about one quarter of the wine produced, and international sales are increasing. Efforts to geographically characterize the region's wine and spirits and to develop and adapt foreign varieties are increasing as evidenced by the numerous papers published by Gonzalez-Neves *et al*. (2010) Lucena *et al*.(2010), Fanzone *et al*. (2012), and Granato *et al*. (2011).

The Latin American wine industry is backed by organizations, such as institutes and departments of viticulture and enology in public and private universities, that train technicians in the management of vineyards and wineries. Thus, the current relevance of the Latin American wine industry justifies an analysis of the scientific and research activities in this part of the world.

Papers published in scientific journals are one of the measurable outcomes of research activity and may be analyzed using qualitative and quantitative methods. The qualitative method of "peer review", which is based on expert opinion, is an indispensable basic condition that is imposed by editors before research will be published in prestigious scientific journals. The quantitative determination is based on a series of measures or indicators that are derived from statistical analysis of published scientific literature and included in bibliographic databases (White and McCain, 1989). These indicators reflect the scientific activity of researchers and their institutions by determining which papers they have published, the characteristics of the literature and the number of collaborative relationships represented by the papers. Authors confer accreditation to colleagues' publications by citing them, so citation counts reflect the impact that published papers have had on subsequent publications and their authors (Aleixandre-Benavent *et al*., 2007).

Scientific collaboration facilitates the flow of information among researchers and also allows for cost-sharing and improved efficiency in research (Kretschmer, 1994; Mewman, 2004). One way to determine the level of established cooperation is to count the number of co-authorships in an area of scientific research. The co-authorship relationship occurs when two or more authors or institutions contribute to the same scientific paper (Newman, 2004). Using social network analysis, these interpersonal and inter-institutional collaborations can be represented by graphs that quantify how many members make up a network, the intensity of their relationships and which members are the most relevant (Newman, 2004; González-Alcaide *et al*. 2008a). Researchers with the largest number of collaborative publications are at the "research front' of that field (González-Alcaide *et al*., 2008b).

The aim of this study was to analyze the scientific activity of Latin American researchers in viticulture and enology through bibliographic analyses of articles in the Science Citation Index Expanded (SCI-E) database for the period of 2006 to 2010. The length of this time period allows us to obtain comprehensive information with which to establish trends in research in the field. Moreover, the joint analysis of productivity, collaboration and scientific impact provides a global and integrated vision of the countries' research in this area.

Materials and methods

The articles used for analysis were obtained from the Science Citation Index Expanded (SCIE)

database, which was accessed via the Web of Knowledge platform from terminals at the Pontificia Universidad Católica of Chile in Santiago. Only papers categorized as articles or reviews were considered; sources such as letters, editorial material, book reviews, proceedings, reprints, news and bibliographic articles were excluded.

To research publications in the field of "wine research", we used a strategy consisting of several components (Glanzel and Veugelers, 2006; Aleixandre *et al*., 2012): a) searches by specific words, b) searches by institutional addresses, c) searches in specific viticulture and enology journals, d) searches involving Latin-American countries, e) searches limited to a 5-year period.

a) For the searches involving specific words, we used the following terms:

   TS=(grapevin* or wines or "wine grap*" or "wine pro*" or "red wine*" or "white wine*" or winemaking or enolog* or viticult* or oenolog* or "wine cell*" or "wine yeast*" or winery or wineries). TS is the label for the field "topic", and records are retrieved if the above terms are included in the titles, keywords or abstracts of articles. Some roots were cut with an asterisk to obtain all of the documents associated with the derived words (*e.g*., by searching for enolog*, the SCIE database finds enology, enologist, enological, etc.).

b) For the searches for institutional addresses, we used the following terms:

   AD=(enolog* or viticult* or oenol*), where AD is the label for the institutional addresses of the authors.

c) For the searches in specific viticulture and enology journals, we used:

   SO= American Journal of Enology and Viticulture or Australian Journal of Grape and Wine Research or Ciencia e Técnica Vitivinícola or Journal International des Sciences de la Vigne et du Vin or South African Journal of Enology and Viticulture or VITIS. SO is the label for the name of the journal.

d) For the search limited to articles that were authored in Latin-American countries, we used the following:

   CY= Argentina or Bolivia or Brazil or Chile or Colombia or Costa Rica or Cuba or Ecuador or El Salvador or Guatemala or Haiti or Honduras or Mexico or Nicaragua or Panama or Paraguay or Peru or Dominican Republic or Uruguay or Venezuela. CY is the label of the countries of the authors' institutions.

e) Finally, the analysis was limited to a 5-year period, 2006 to 2010.

   The searches using specific words, institutions and journals (a, b, c) were combined with the logical operator "or". These results were combined with countries (d) and time period (e) using the "and" operator.

The records obtained were exported to a relational database in Microsoft Access. The different variants of the same author or institution were unified because this information is not always standardized in SCIE. The information was analyzed to obtain bibliometric indicators of scientific productivity, patterns of collaboration, number of citations and impact. Data about the scientific productivity of the journals, institutions and countries were weighted based on whether English was the language of publication. A social network analysis was also carried out to identify the number of co-authorships, *i.e*., all combinations of pairs of authors or institutions on each paper, a process that is essential to identify research groups. The software Pajek (Batagelj and Mrvar, 2001) was used to construct and graphically represent the research groups and to visualize the networks.

Table 1. Annual distribution of journals by publication language, 2010 impact factor and country.

						Total				
Journal	2006	2007	2008	2009	2010	Total all languages	Only in English	% in English	Impact Factor	Country
Revista Brasileira de Fruticultura		9	14	12	19	54	3	5.56	0.440	Brazil
Journal of Agricultural and Food Chemistry	8	8	8	3	5	32	32	100	2.816	USA
Food Chemistry	2	2	6	7	6	23	23	100	3.458	United Kingdom
Ciencia e Tecnologia de Alimentos		7	4	3	6	20	3	15	0.266	Brazil
Ciencia Rural			3	6	8	17	1	5.88	0.343	Brazil
Quimica Nova	2	4	5	1	3	15	0	0	0.744	Brazil
American Journal of Enology and Viticulture	4	5	2	2	1	14	14	100	1.667	USA
International Journal of Food Microbiology	1	5	2	3	3	14	14	100	3.143	Netherlands
Analytica Chimica Acta	2	4	4		3	13	13	100	4.311	Netherlands
Pesquisa Agropecuaria Brasileira	2	1	3	6	1	13	2	15.38	0.687	Brazil
Ciencia e Agrotecnologia		3	6	3	1	13	2	15.38	0.567	Brazil
Talanta			5	2	5	12	12	100	3.722	United Kingdom
Revista de la Facultad de Ciencias Agrarias		2	5	5		12	1	8.33	0.020	Argentina
Scientia Agricola	1	1	3	2	4	11	11	100	0.816	Brazil
Food Control		4	2	3	1	10	10	100	2.812	United Kingdom
Journal of Industrial Microbiology & Biotechnology	1	2	3	4		10	10	100	2.416	Germany
Semina-Ciencias Agrarias		1	3	2	4	10	10	100	0.185	Brazil
Journal of Chromatography A	2	3	3		1	9	9	100	4.194	Netherlnads
World Journal of Microbiology & Biotechnology	2	2	2	1	2	9	9	100	1.214	Netherlands
Journal International des Sciences de la Vigne et du Vin	1	1	3	2	2	9	8	88.89	0.913	France
Plant Disease		1	2	5		8	8	100	2.387	USA
Ciencia e Investigacion Agraria		1	2	2	3	8	5	62.50	0.528	Chile
International Journal of Food Science and Technology		1	1	1	5	8	8	100	1.223	United Kingdom
Brazilian Archives of Biology and Technology	2	2	1	3		8	8	100	0.397	Brazil
Ciencia e Tecnica Vitivinicola			2	3	2	7	1	14.29	0.636	Portugal
Current Microbiology	3	1	1		2	7	7	100	1.510	USA
Chilean Journal Of ogricultural Research			1	4	2	7	7	100	0.385	Chile
Journal of Applied Microbiology		4	1		2	7	7	100	2.365	United Kingdom
Tropical Plant Pathology			2	3	2	7	5	71.43	0.448	Brazil
Vitis		1	2	2	1	6	6	100	0.662	Germany
Journal of The Brazilian Chemical Society			1	2	3	6	6	100	1.343	Brazil
Letters in Applied Microbiology			1	1	4	6	6	100	1.647	United Kingdom
Agricultura Tecnica		3	3			6	5	83.33	0,451	Chile
Journal of Sensory Studies	2	1	1		2	6	6	100	1.750	USA
Food Research International	1			1	4	6	6	100	2.416	USA
Electroanalysis	1		2	1	2	6	6	100	2.721	Germany
European Food Research and Technology		1	1	3	1	6	6	100	1.585	Germany
Journal of the Science of Food And Agriculture	1			1	3	5	5	100	1.360	United Kingdom
Lebensmittel-Wissenschaft und-Technologie-Food Science and Technology	1			2	2	5	5	100	2.292	United Kingdom
Journal of Food Engineering	1	1	1		2	5	5	100	2.168	United Kingdom
Food Microbiology		1	3	1		5	5	100	3.320	United Kingdom
Journal of Food Composition and Analysis			3		2	5	5	100	1.948	USA
Food Quality and Preference				1	4	5	5	100	3.013	United Kingdom
Spanish Journal of Agricultural Research	1	2		1	1	5	5	100	0.646	Spain
7 journals with 4 articles	5	7	8	5	3	28	26	92.86		
31 Journals with 3 articles	10	14	19	31	19	93	80	86.02		
44 journals with 2 articles	7	22	15	19	25	88	83	94.32		
238 journals with 1 article	30	47	40	47	74	238	219	92.02		
Total	93	174	199	206	245	917	733	79.93		

Results

Scientific productivity

During the period analyzed, 917 research articles were published, and the number grew slightly from 93 in 2006 (10.1%) to 245 (26.7%) in 2010. The average number of articles per year was 183.4 (Table 1). The articles were published in 364 different journals of which 44 published 5 or more papers. Revista Brasileira de Fruticultura was the journal that published the greatest number of articles (n=54; Brazil) followed by the Journal of Agricultural and Food Chemistry (n=32; USA), Food Chemistry (n=23; United Kingdom) and Ciencia e Tecnologia de Alimentos (n=20; Brazil). Another 40 journals account for more than 4 papers each (Table 1). The specific viticulture and enology journals that published a large number of articles were the American Journal of Enology and Viticulture (n=14; USA), Journal International des Sciences de la Vigne et du Vin (n=9; France), Ciencia e Tecnica Vitivinicola (n=7; Portugal) and VITIS (n=6; Germany). A quarter of these journals were published in Brazil (n=11), another quarter in the United Kingdom and 7 in the USA. Most of the articles were published in English (n=719, 78.4%) but also notably Portuguese (n=157, 17.1%) and Spanish (n=34, 3.7%). However, of the 11 most productive journals published in Brazil, only 5 published more than 50% of their articles in English, while this was the percentage for all of the journals published in Chile (n=3).

The SCIE subject areas that comprised more than 10% of published articles were as follows: 267 articles (29.1%) were classified in the area of Agriculture, 219 (23.9%) in Food Science and Technology, 191 in Chemistry (20.8%) and 98 (10.7%) in Biotechnology and Applied Microbiology.

1,803 institutions were identified of which 27 published more than 15 articles (Table 2). Most of the institutions were located in Brazil, Argentina and Chile. The Universidade de São Paulo, Brazil, ranked highest in institutional productivity with 84 articles followed by the Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina) (n=57), the Universidade Estadual de Campinas (Brazil) (n=53), the Universidade Federal do Rio Grande do Sul (Brazil) (n=52) and the Embrapa Uva & Vinho (Brazil) (n=51). If English was the language of publication of the articles, the most productive Latin American institutions, with more than 95% of the published articles, were the Pontificia Universidad Católica de Chile, the Universidad de Concepción (Chile), the Universidad Nacional de Tucumán (Argentina), the Instituto de Investigaciones Agropecuarias (INIA, Brazil) and the Centro de Referencia para Lactobacilos (CERELA, Argentina).

Of the 30 different countries that contributed to the publication of papers (Table 3), 9 were Latin American, and 21 were non-Latin American collaborators. Brazil ranked first with respect to scientific productivity (n=439), followed by Chile (n=179), Argentina (n=144) and Mexico (n=90). If only the percentage of articles published in English is considered, the ranking was headed by Chile (94.97%) and followed by Mexico (94.44%) and Uruguay (n = 93.75%). The USA (n=83), Spain (n=73) and France (n=53) should be highlighted within the non-Latin American countries. The increase in the number of published papers was highest in Brazil, which rose from 39 papers in 2006 to 116 in 2010, but significant growth also occurred in Argentina (from 14 to 39) and Chile (from 17 to 53) during the same time period. Figure 1 shows the weight of English in the national production of scientific articles compared to production in all languages.

The relative scientific productivity by number of inhabitants and Gross Domestic Product (GDP) was significantly greater in Chile (10.27 articles per million inhabitants and 0.69 per thousand million GPD) and Uruguay (9.43 articles per million inhabitants and 0.67) per thousand million GPD) than in other countries. Taking wine production

Table 2. Annual distribution of articles and citations from the main viticulture institutions according to publication language.

		Articles								Citations					
Institutions	Country	2006	2007	2008	2009	2010	Total all languages	Total English	% In English	2007	2008	2009	2010	Total	Citations/ article
Universidade de São Paulo (USP)	Brazil	14	12	14	17	27	84	70	83.33	79	52	98	59	419	4.99
Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)	Argentina	2	9	12	12	22	57	53	92.98	82	74	35	65	272	4.77
Universidade Estadual de Campinas (UNICAMP)	Brazil	6	20	11	7	9	53	45	84.91	206	77	58	9	425	8.02
Universidade Federal do Rio Grande do Sul (UFRGS)	Brazil	1	8	12	15	16	52	28	53.85	89	98	27	16	231	4.44
Embrapa Uva & Vinho	Brazil	2	8	13	17	11	51	10	19.61	41	47	30	7	127	2.49
Pontificia Universidad Católica de Chile	Chile	2	16	11	7	13	49	48	97.96	174	75	49	29	342	6.98
Universidad de Chile	Chile	4	7	8	12	11	42	39	92.86	94	37	32	42	281	6.69
Universidade Federal de Santa Catarina (UFSC)	Brazil	1	7	15	5	7	35	22	62.86	88	90	12	10	213	6.08
Institut National de la Recherche Agronomique (INRA)	Francia	2	5	11	5	7	30	29	96.67	49	53	24	19	213	7.1
Universidad Nacional de Cuyo	Argentina	2	3	10	8	7	30	17	56.67	20	16	12	15	81	2.7
Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA)	Brazil	2	7	6	9	4	28	19	67.86	20	12	18	6	67	2.39
Instituto Nacional de Tecnología Agropecuaria (INTA)	Argentina	1	4	4	9	10	28	26	92.86	58	15	17	17	109	3.89
Universidade Federal de Lavras (UFLA)	Uruguay	-	2	9	9	8	28	11	39.29	11	14	24	21	70	2.5
Universidad de la República (UDELAR)	Chile	7	3	4	4	9	27	25	92.59	198	45	27	16	339	12.55
Universidad de Santiago de Chile (USACH)	Chile	2	1	8	8	8	27	24	88.89	14	13	45	13	88	3.26
University of California, Davis	United States	8	4	5	7	3	27	25	92.59	64	79	41	28	456	16.89
Universidad de Talca	Chile	5	4	4	3	9	25	23	92	3	39	8	10	154	6.16
Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP)	Brazil	4	5	5	6	5	25	19	76	36	7	18	8	84	3.36
Universidad de Concepción	Chile	1	1	3	8	6	19	19	100	13	26	20	9	73	3.8
Universidad Nacional de Tucumán (UNT)	Argentina	1	6	6	2	4	19	19	100	85	22	9	7	125	6.58
Instituto de Investigaciones Agropecuarias (INIA)	Brazil	1	4	4	3	6	18	18	100	32	5	9	8	78	4.33
Universidade Federal de Minas Gerais (UFMG)	Brazil	-	7	4	3	4	18	15	83.33	78	16	8	4	106	5.89
Universidade Federal da Bahia	Brazil	2	5	3	3	4	17	14	82.35	21	29	6	4	84	4.94
Empresa de Pesquisa Agropecuária de Minas Gerais (EPAMIG)	Brazil	-	1	4	6	5	16	2	12.50	3	7	5	1	16	1
Instituto Agronômico de Campinas (IAC)	Brazil	-	5	6	3	2	16	7	43.75	17	10	4	-	31	1.94
Universidade Federal de Santa Maria (UFSM)	Brazil	2	6	4	3	1	16	4	25	24	5	7	-	69	4.13
Centro de Referencia para Lactobacilos (CERELA)	Argentina	-	6	5	1	3	15	15	100	85	13	6	6	110	7.33
Universidad de Buenos Aires	Argentina	4	2	1	4	4	15	13	86.67	61	9	20	10	221	14.73
Universidad Nacional del Comahue	Argentina	2	6	1	2	4	15	15	100	41	6	6	6	75	5

Table 3. Annual production of articles by country according to publication language and number of citations.

	Articles								Citations					
Country	2006	2007	2008	2009	2010	Total all languages	Only in English	% In English	2006	2007	2008	2009	2010	Total
Brazil	39	86	101	97	116	439	276	62.87	330	676	442	316	131	1,895
Chile	17	34	38	37	53	179	170	94.97	221	327	202	125	111	986
Argentina	14	26	26	39	39	144	126	87.50	226	294	147	131	86	884
Mexico	13	16	21	23	17	90	85	94.44	137	71	134	160	35	537
United States	15	16	17	21	14	83	81	97.59	287	224	161	96	57	825
Spain	5	18	8	10	32	73	68	93.15	64	262	40	62	68	496
France	5	6	16	13	13	53	51	96.23	75	75	85	109	38	382
Uruguay	8	3	6	4	11	32	30	93.75	55	198	51	27	17	348
Italy	3	11	2	10	3	29	27	93.10	6	154	6	47	8	221
Colombia		2	2	5	9	18	14	77.78		13	6	29	15	63
Australia	1	1	3	4	4	13	13	100	30	22	48	38	16	154
Portugal	2		2	3	6	13	13	100	16		10	35	29	90
Germany	1		2	2	6	11	11	100	3		17	15	23	58
Venezuela	1	2	2	3	3	11	10	90.91	30	5	4	0	4	43
Netherlands	1	1	1	2	4	9	9	100	6	2	2	11	14	35
Canada	1		2	2	2	7	7	100	3		18	21	8	50
Costa Rica		2	1	2	2	7	7	100		13	0	21	1	35
Peru		3	2	1	1	7	6	85.71		69	8	17	0	94
United Kingdom		2	2	1	2	7	7	100		74	37	13	6	130
India		2	1	1	2	6	6	100		0	12	13	13	38
China		3		2	1	6	6	100		2		21	5	28
Cuba	1			1	2	4	4	100	0			17	4	21
Russia		2		2		4	4	100		0		19		19
Sweden		2	1	1		4	4	100		97	9	13		119

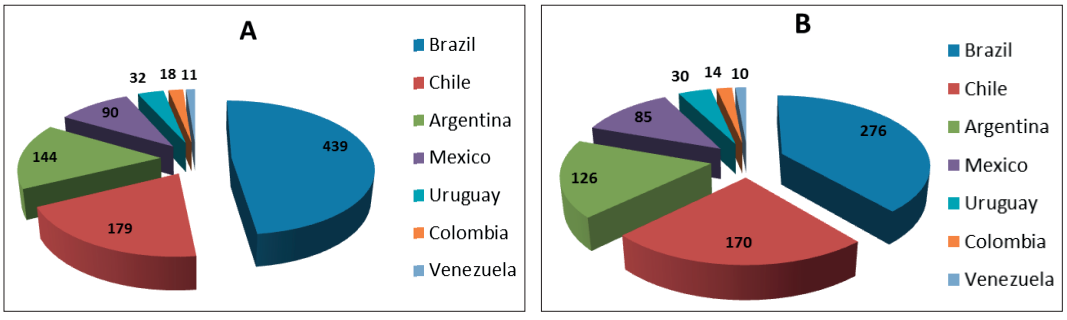

Figure 1. Distribution of articles in English and all other languages in Latin American countries. A: articles in all languages. B: articles in English

into account, Argentina and Chile are the major wine producers of Latin America, accounting for 92.3% of production, outweighing the wine sectors from other producing countries (Table 4).

Patterns of collaboration

Most of the published articles were the result of a national collaboration (n=415, 45.2%), *i.e.*, two or more institutions in the same country participated. In 281 articles, we identified the participation of a foreign institution (30.6%), and 328 papers were authored by a single national institution (35.8%). The number of national and international collaborations increased over time, but the number of papers published by a single institution remained virtually stable (Figure 2).

The social network analysis resulted in the identification of a total of 8 institutional collaborative groups of which the largest was made up of 61 linked institutions (Figure 3). The numbers on the lines that link the institutions indicate the number of articles published in collaboration.

In the largest group, two institutions occupy a central position. On one side of the network, the Universidade de São Paulo (Brazil) established collaborations, with 7 papers each, with 12 institutions including the Universidade Estadual Paulista Júlio de Mesquita Filho, the Universidade

Table 4. Scientific productivity by country according to GPD, number of inhabitants and percentage of wine production.

Country	Number of Inhabitants 2010 (A) in millions	Number of articles (B)	B/A (articles by million inhabitants)	GDP (PPP) 2010 in millions of dollars USA (C)	B/C (articles by thousand million GPD)	Wine production (%)
Argentina	41.12	144	3.5	642.402	0.22	50.39
Brazil	198.36	439	2.21	2.172.058	0.20	1.13
Chile	17.43	179	10.27	257.884	0.69	41.91
Colombia	47.55	18	0.38	435.367	0.04	-
Mexico	116.15	90	0,77	1.629.184	0.05	3.9
Uruguay	3.39	32	9.43	47.986	0.67	3.75
Venezuela	29.89	11	0.36	345.210	0.03	-

Source: Organisation Internationale de la Vigne et du Vin.

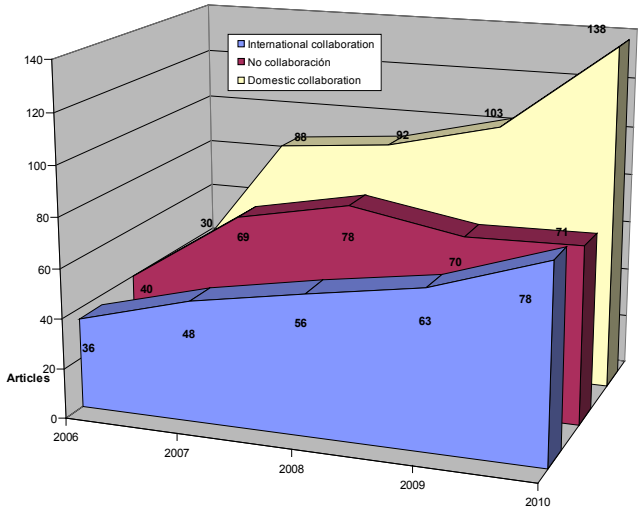

Figure 2. Annual distribution of domestic versus international collaborations.

Federal de Lavras and Universidade Estadual de Campinas. On the other side, the Consejo Nacional de Investigaciones Científicas y Técnicas (Argentina) collaborated widely with the Universidad Nacional de Comahue (n=12) and the Instituto de Agroquímica y Tecnología de Alimentos from Consejo Superior de Investigaciones Científicas (Spain, n=9). Other important collaborations were established between the Argentinian Universidad Nacional de Tucaman and the Centro de Referencia para Lactobacilos (n=14), the Brazilian Embrapa Uva & Vinho and the Universidade Federal do Rio Grande do Sul (n=17), and the Universidade Federal de Lavras and the Empresa de Pesquisa Agropecuaria de Minas Geraias (n=13). Figure 4 shows the groups with smaller numbers of components. The group with 7 components had the Universidad de Santiago de Chile as its central institution, which established collaborations with several centers from Chile, Spain (subsidiaries of the Spanish Research Council-CSIC) and the Australian Wine Research Institute.

Figure 4 shows the network of collaborations between countries and their intensity. The degree of cooperation is highest between Chile and Spain (n=20) followed by Argentina and Spain (n=19), Brazil and the USA (n=19) and Mexico and the USA (n=19).

Citations and impact

The most productive journals with the greatest impact factors (IFs from 2010) were Analytica Chimica Acta (IF=4.311) and the Journal of Chromatography A (IF=4.194). Four other journals had IFs greater than 3 points: Food Chemistry, Talanta, Food Microbiology, International Journal of Food Microbiology and Food Quality and Preference (Table 1). The journals with the highest IFs are usually published in the United Kingdom, the Netherlands and the USA.

The most cited Latin American institution was the Universidade Estadual de Campinas (n=425 cita-

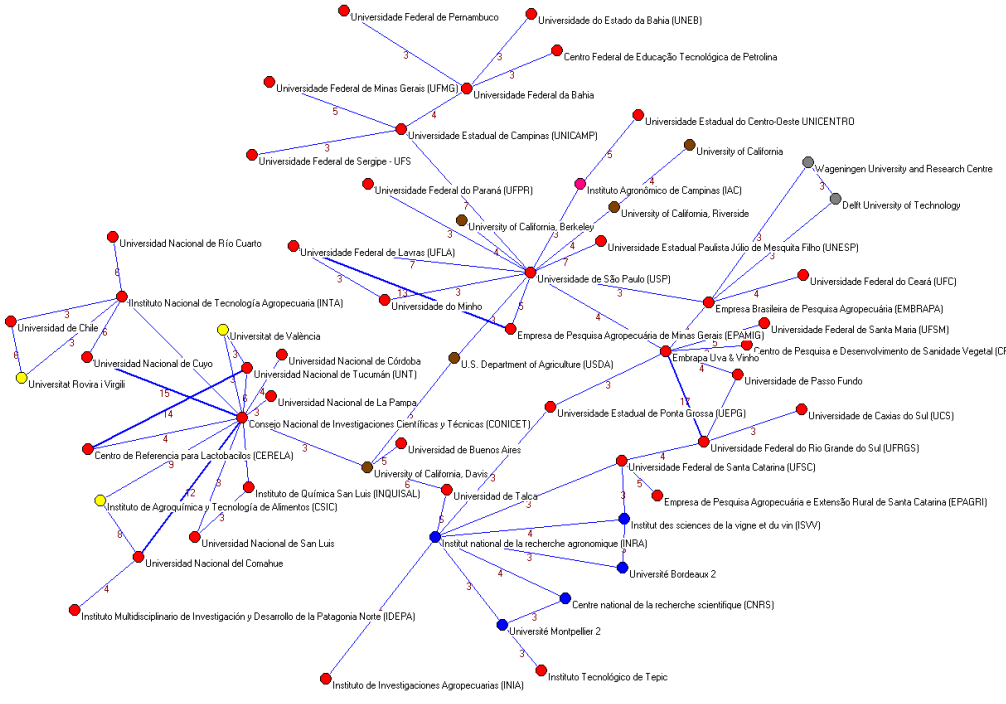

Figure 3. Main institutional network by region. Color of institutions: Red, Latin American; Yellow, Spanish; Blue, French; Grey, Netherlands; Brown, USA.

tions) followed by the Universidade de São Paulo (n=419), the Pontificia Universidad Católica de Chile (n=342) and the Universidad de Chile (n=339) (Table 2). The Universidad de Buenos Aires (Argentina) had the highest number of citations per paper with an average of 14.73 followed by the Universidad de Chile (n=12.55) and the Universidade Estadual de Campinas (Brazil) (n=8.02).

The countries with the highest total citations were Brazil (n=1895), Chile (n=986) and Argentina (n=884). However, the number of citations per article was higher in Peru (n=13.43 citations per paper) and Uruguay (n=10.87) (Table 3).

Discussion

The economic, political and social context of Latin America has delayed scientific and technological development. However, beginning in the 1990s, new policies for funding research were implemented that are now paying off (Albornoz, 2001), and the Latin American scientific community is gaining significance in many areas. The number of papers published in international journals by Latin American authors included in the SCIE doubled during the period from 1997-2007 (Babini, 2011). This is consistent with data from our work that shows remarkable growth in the publication of scientific research papers over the five years analyzed (from 10 to 26.7%). This growth has been observed in other areas of research, such as ceramics (Rojas-Sola *et al*., 2009), psychology (Sanchez Sosa, 2008; Vera-Villarroel *et al*., 2011) and health technology (Pichon-Riviere, 2009).

Other reasons for this growth could be the increasing number of Latin American journals included in the SCIE, which has grown from 48 journals in 2006 to 179 in 2010. For most countries, such as Argentina, Chile, Mexico and Venezuela, the number of included journals has been multiplied by 3. However, the growth was most evident in Brazil where the number of journals increased by a factor of 4, from 21 in 2006 to 89 in 2010. However, coverage of Latin American journals in international bibliographic databases (the SCIE in particular) remains low. Consequently, high quality papers originating in Latin American countries are usually published in the USA or in European

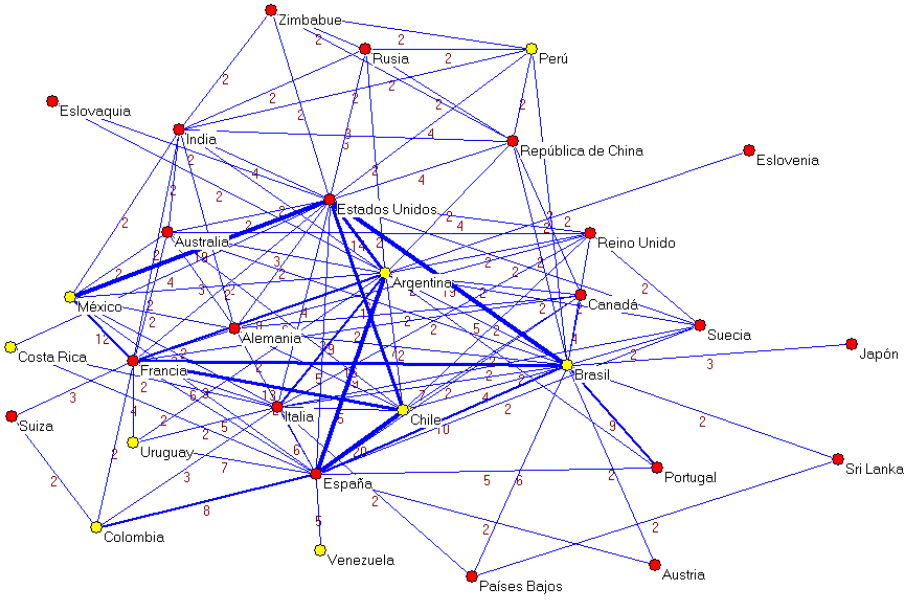

Figure 4. Network of collaborations between countries.

journals. These journals hold a privileged position in the scientific mainstream, so they are able to attract papers from leading scientists.

If research is to progress, collaboration between institutions from different countries is necessary (Cunningham and Dilon, 1997; Katz and Martin, 1997; Newman, 2004). Differences in the level of scientific and technological cooperation between nations has been reported in various international forums in which appeals are also made to encourage international collaboration (Albornoz, 2001; Gonzalez-Alcaide *et al*., 2008). Stimulating the formation of groups and networks that bring together scientists, technologists and other stakeholders from different countries and promote the joint use of their knowledge is a central aspect of strategies for cooperation (Valderrama Zurián *et al*., 2008) because these groups advance knowledge, improve quality, and increase innovation and competitiveness (Cunningham and Dillon, 1997).

The papers we studied were published not only in viticulture and enology journals but in numerous journals from other subject areas such as food science and technology, food chemistry, microbiology, plant diseases, etc., as well as general agricultural research journals. This diversity is logical due to the multidisciplinary nature of the study area and the existence of extensive collaborations and synergies between viticulture and enology and other disciplines (Glanzel and Veugelers, 2006; Aleixandre-Benavent *et al*., 2012). This diversity in subject areas should instruct researchers seeking information on viticulture and enology to expand their search to related or general knowledge journals such as those identified in this study.

Brazil stands out as a country with the greatest scientific productivity and absolute number of citations in Latin America. Brazil's leadership can be explained by the fact that research spending and development in the country represents 60% of the investment in the entire region (Babini, 2011), by the magnitude of other indicators such as population size, which is 5 times the number of inhabitants in Argentina and more than 10 times the number in Chile, the other two large Latin American wine producers, or by the number of journals included in the SCIE (89 in 2010 versus 21 in Chile and 14 in Argentina). For these reasons, Brazilian institutions have often had greater absolute scientific productivity and impact in terms of the number of citations. However, the relative productivity measure of citations per paper shows that institutions in the other two countries compete with those in Brazil. However, when English language publications are taken into account, only a small percentage of the articles in the six most productive Latin American journals, all published in Brazil, are published in English. From this we can deduce that these are local journals, which despite being indexed in SCIE, likely do not have a high impact. This distortion not only affects the ranking of the most productive Latin American journals, but it also affects institutions; the Pontificia Universidad Católica de Chile leads in the ranking of Latin America's most productive institutions with a higher percentage of articles published in English and is ahead of other Brazilian institutions such as the Universidade de São Paulo, the Universidade Estadual de Campinas, the Universidade Federal do Rio Grande do Sul, and other Argentine institutions such as the Consejo Nacional de Investigaciones Científicas y Técnicas. Similarly, in the ranking of countries, Brazil is surpassed by Chile, Mexico, Uruguay and Argentina.

Social network analysis identified the most relevant research centers and universities that had scientific collaborations. These institutions could be considered to be on the "research front" in viticulture and enology in Latin America (Gonzalez-Alcaide *et al*., 2008). Increasing numbers of international collaborations observed throughout the study period are a positive sign indicating openness to foreign research from Latin American countries in this discipline. Additionally, collaboration with

Latin American countries is particularly evident in countries among the scientific elite such as the United States, the European Union and Australia, and it occurs through several institutions in the USA (*e.g.*, University of California in Davis, Berkeley and Riverside and the US Department of Agriculture), Spain (e.g., Spanish Research Council-CSIC through the Instituto de Agroquímica y Tecnología de Alimentos, the University of Valencia and the University Rovira Virgili) and France (*e.g.*, the Institut National de la Recherche Agronomique-INRA, the Institut des Sciences de la Vigne et du Vin, the University of Bordeaux and the University of Montpellier). Implicit in these collaborations is the establishment of agreements that allow for the exchange of researchers and students as well as many collaborative research projects. An example of this dynamic in the fields of viticulture and enology is the agreement between the European Union and the Pontificia Universidad Católica of Chile, Stellenbosch University of South Africa and the École d'Ingénieurs de Changins of Switzerland for the Erasmus Mundus Vintage International Masters of Science Programme (http://www.vintagemaster.com). Erasmus Mundus is a program that aims to improve the quality of European higher education and promote understanding between people and cultures through cooperation with developing countries. These agreements enable researchers, teachers and students from the European Union, Chile, Switzerland and South Africa to take part in scientific programs and, therefore, increase their mobility. The promotion of these academic and research opportunities in foreign centers is considered critical to the internationalization of science (Ponds, 2009).

Despite the growing degree of international collaboration between Latin American countries and those of the scientific elite (mainly the United States, European Union, Australia and Canada), intensive ongoing cooperation between Latin American countries is lacking. For example, Chile collaborated with Spain on 19 papers, with the USA on 15 and on 13 with France but on only 7 with its neighbor, Argentina. The same phenomenon can be observed with Brazil, a country that collaborated on 19 articles with the USA, 16 with France and 10 with Spain but only on 5 papers with neighboring Argentina. This preference for Latin American countries to establish their links with scientifically elite countries is possibly driven by their research policies (Glanzel and Veugelers, 2006).

Knowledge of research networks in a specific scientific field provides several advantages for academics and researchers. First, it provides them with trustworthy information about existing active research groups in the discipline and opens opportunities for increasing their circle of contacts, participating in discussion forums and exchanging ideas on relevant topics as well as integrating into any of the identified groups (González-Alcaide *et al*., 2008; Wagner and Leydesdorff, 2005). On the other hand, network analysis identifies the institutions that occupy more central places in the network, which can be helpful when deciding on the convenient research centers with which to establish collaborative arrangements or conduct multicentric studies. The centers of a collaboration network with many connections will be preferentially chosen by new research groups seeking to initiate a scientific collaboration, and a group rich in connections will increase their influence more rapidly (Barbasi, 1999). Other benefits arise from the fact that identifying groups with similar scientific interests prevents the duplication of experiments, which increases the effectiveness of research and the impact of citations (Figg *et al*., 2006; Teasley and Wolinsky, 2001).

As we have seen, Latin American authors should use domestic and international journals to disseminate their research. Domestic journals should have a moderate impact factor compared to journals from the USA, the United Kingdom and the Netherlands. The explanation for this phenomenon could be that journals from non-Latin American countries are usually published in English, the current international language of science, as opposed to Latin American journals that are published in Portuguese and Spanish. Logically, only a certain number of

researchers can read and cite such articles. Several studies have analyzed the relationship between the language of publication and the number of citations and have demonstrated that works published in journals edited in English are cited more often (Gonzalez-Alcaide *et al*., 2012).

This paper has some limitations that should be discussed. First, the SCIE does not include all of the published scientific literature on viticulture and oenology, so other bibliographic databases and additional data gathering from Latin American science journals could have been used as an alternative or a supplement. However, we used the SCIE because it has the following advantages: a) The SCIE is widely used in studies analyzing activity in science and technology because it includes the highest impact journals, which helps focus analyses on the most relevant authors and research centers (Rivera *et al.*, 2010; Llorente-Bousquets, 2010; Rojas-Sola *et al*., 2009); b) It provides the names of all of the authors on the papers and all their institutional affiliations, which allowed us to determine the indicators of cooperation between researchers and their institutions; c) It makes the number of citations that articles have received available, and an additional resource, the Journal Citation Reports, provides the impact factors of journals, information that does not exist in other databases. Second, this study did not allow us to investigate the contribution of Latin-American viticulture and enology research to the progress of scientific knowledge. However, this limitation can be seen as a fruitful avenue for future research. It should also be noted that the absence of an impact factor for some journals or papers does not mean a lack of quality or a lack of a role in the transmission of knowledge. Impact indicators provide, above all, a measure of the utility rather than quality of the publications.

Regardless of these limitations, this paper identified the journals, institutions and countries with the greatest productivity and impact in the field of Latin-American viticulture and enology in recent years, as well as the members of research groups with the greatest number of collaborations and who can be considered the leaders or the heads of research in the discipline.

In conclusion, this study provides an indication of the state of research in Latin America in the field of viticulture and enology based on the analysis of articles published in journals included in the SCIE. The results highlight the significant growth in the number of research papers published from 2006 to 2010, although this growth is due in part to the increase in the number of journals included in the SCIE, some of which are published in local, non-English journals. When the influence of being published in English is considered, significant differences were observed in the productivity rankings of journals, institutions and countries. There was an increasing trend in the degree of international collaboration in Latin America, mainly with non-American viticulture and enology institutions and countries. Future work in this area could identify newly emerging groups and the evolution of already recognized groups over time.

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Resumen

J.L. Aleixandre, E. Bordeu, J.L. Aleixandre-Tudó, M. Bolaños y R. Aleixandre-Benavent. 2013. Productividad y colaboración científica en viticultura y enología en los países latinoamericanos. Cien. Inv. Agr. 40(2): 429-443. El objetivo de este trabajo fue analizar la actividad científica de los investigadores en los países latinoamericanos en viticultura y enología mediante análisis bibliométrico de los artículos incluidos en la base de datos Science Citation Index Expanded durante el período 2006 a 2010. Un total de 917 artículos de investigación fueron publicados en 364 revistas nacionales e internacionales. Destaca un crecimiento importante en los trabajos de investigación publicados en el período, sobre todo en Brasil, Argentina y Chile, así como una colaboración internacional cada vez mayor, sobre todo con los países productores de uva y vino no americanos. También se llevó a cabo un análisis de redes sociales de la colaboración entre instituciones y países. El análisis combinado de la productividad, la colaboración científica y el impacto ofrece una visión global e integrada de los países que investigan en esta área.

Palabras clave: factor de impacto, países de América Latina, análisis de redes, colaboración científica, productividad científica, viticultura y enología.

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