

Coffee crop science metric: A review

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ABSTRACT

Coffee is one of the leading worldwide drinks; therefore, it represents highly valued trade. However, coffee is a complex food from sowing to harvesting, processing, packaging, selling and consuming, although coffee is important in most of its stages, no studies have analyzed the dynamics of global coffee research. This paper presents an analysis of the evolution of Coffee related international research. It is based on the renowned literature databases published by Scopus and Web of Science. The parameters studied included growth of publications, the main journals, countries, institutions, and an author keywords analysis according to their relationship with topics such as agronomy, health, economy, chemistry or biological compound, product and unclassified words. Interest in harvesting techniques and coffee side factors have been increasing through last years in an exponential trend. Producer and consumer countries have composed a synergy with their research interest, that allows stating an upcoming growing in techniques headed to the quality beverage. The contribution is to visualize state of the art in the area of coffee knowledge to generate trends for future research.

Key words: Agronomy; scientopy; countries.

1 INTRODUCTION

Coffee is one of the oldest beverages. Which has apocryphal stories about its findings. It is originated in tropical Africa. Specifically, in Ethiopian highlands in about AD 850, from whence it was taken home by pilgrims to other parts of the Islamic world (Smith, 1985). Despite the first regulations by Arabs to control this product, other communities such as Dutch and French were able to cultivate it. Consequently, it has evolved through the years and regions where the coffee is produced and traded (Vieira, 2008).

Nowadays, coffee makes part of the lifestyle of people worldwide. As a beverage has its highest consumption rates in Europe and the United States (Samoggia; Riedel, 2018). As a crop, coffee is the most extensive agricultural trade (Murthy; Naidu, 2012a). It is cultivated in over 80 countries, where it represents a significant source of income for family farming (Damatta, 2004).

Due to the global importance of coffee, research has scaled most of the topics related to harvesting stages, sowing (Siles; Harmand; Vaast, 2010), maturing (Damatta; Ramalho, 2006; Damatta et al., 2007; Damatta, 2004; Moguel; Toledo, 1999), analyses on chemical composition (Rendón; Salva; Bragagnolo, 2014; Romano et al., 2014; Milenkovic et al., 2012; Cárdenas; Quesada; Medina, 2011), manufacturing process and trade (Taylor, 2005; States, 2017; Valkila; Haaparanta; Niemi, 2010; Utting, 2009). Side factors as pests and diseases (Waller, 1985; Kellermann et al., 2008; Posada et al., 2007; Avelino et al., 2015; Avelino et al., 2006; Silva et al., 2002; Schroth

et al., 2000; Jaramillo et al., 2011; Jaramillo et al., 2009), ecosystem (Durán et al., 2005; Hoyos; Comerford, 2005; Muriel; Kattan, 2009; Alexander et al., 1998; Lautenbach et al., 2012; Perfecto et al., 2003; Méndez; Somarriba, 2001) and human health impacts (Higdon; Frei, 2006b; Poole et al., 2017; Rhee et al., 2016; Cenoz, 2013; Li et al., 2013; Ong; Hsu; Tan, 2012) associated to coffee crop have been also highlighted coffee as an interdisciplinary topic of research. Region, countries, and institutions have been focused on different aspects depending on their consumer-producer relationship, making coffee a topic that requires cooperation between parties.

Although coffee is important in most of its stages, no studies have analyzed the dynamics of global coffee research. Therefore, for this study, the research question considered was:

What are the main journals, countries, and author keywords on coffee in research articles published during 1990-2017?

We consider that this article contributes to enlarge knowledge about latest trends in coffee research, which can be used by policymakers in producer countries to allow improvements in bean quality. For consumer countries, this document gives a glance about research done related to impacts of this common beverage.

This study includes the following: (1) to identify the popular journals, representative countries, and primary institutions in the coffee research field; (2) to analyze the author keywords base and influential topics related to coffee; and (3) to uncover how the main author keywords have evolved over the last decades in different fields.

2 MATERIAL AND METHODS

The bibliometric analysis consists of a statistical method used to measure research quality impact through the process of identifying, organizing, and analyzing the main components within a particular research field (Ruiz-Rosero; Ramirez-Gonzalez, 2018). The bibliometric method allows evaluating the contributions achieved by agents such as countries, institutions, and authors.

The tool used to analyze document bibliographies was a different literature review script called ScientoPy. It is a Python script that automatically reports the top topics (based on author keywords), authors, and countries, along with related documents. This automatic data synthesis avoids potential bias as in individual studies (Ruiz-Rosero et al., 2017; Ruiz-Rosero; Ramirez-Gonzalez, 2018).

2.1 Dataset

For bibliometric analysis, two databases were used: Clarivate Web of Science (WoS), and Scopus, which are considered as the world's largest abstract database and citation databases of peer-reviewed research literature. The span selected was 1 January 1990 to 31 December 2017. The following document types were studied: conference paper, article, review, proceedings paper, article in press.

The search was carried out with the string: "coffee". This string was applied to the topic search in WoS and Scopus, which include title, abstract, author keywords, and keywords plus R (for WoS). With this search criteria, the data set was extracted within a day on 6 September 2018. The documents found in the two databases totaled 60576 documents.

2.2 Pre-Processing

In order to improve the reliability and precision, ScientoPy applied the following criteria:

- For Scopus fields, replace the comma with a semicolon in author's name
- Remove dots, coma and special accents from author's name
- Remove duplicated samples were identified by identical title and authors

After the dataset samples were preprocessed, the information was consolidated and merged from both databases. Table 1 describes the final sample analyzed in this work included 44654 documents.

By undertaking the current study, we only showed a top ten selected topics, for the study about the evolution of scientific production and the first 400 words for the author keywords analysis based on highest h-index, classified by six categories: agronomy, health, economy, chemistry or biological compound, product, and generic unclassified

words. However, the data set could undertake an in-depth analysis evolution of the research works on Coffee published.

Table 1. presents total loaded papers, omitted papers by document type, percentage relative to total loaded papers, papers from WoS, papers from Scopus, total duplicated papers found percentages relative to total loaded papers, removed duplicated papers from WoS percentage relative to papers from WoS, removed duplicated papers from Scopus percentage relative to papers from Scopus, duplicated documents with different cited by percentage relative to total duplicated papers found, output papers in range 1990 – 2017, and percentage relative to output papers (after duplication removal filter).

Table 1: Type of documents found with the search string "Coffee" loaded papers.

Information	Number	Percentage
Loaded paper result:		
Total papers	60576	
Omitted papers by document type	7162	11.8%
Total papers after omitted papers removed	53411	
Papers from WoS	5191	7.2%
Papers from Scopus	8222	2.8%
Duplicated removal results:		
Total duplicated papers found	757	6.4%
Removed duplicated papers from WoS	6	0.3%
Removed duplicated papers from Scopus	691	0.8%
Duplicated document with different cited by	246	1.3%
Output papers (after duplication removal filter)	44654	
Output papers in range 1990-2017	37013	82.9%

3 RESULTS AND DISCUSSION

The first category analyzed was journals. In this classification, 70 journals published more than fifty articles related to coffee. Table 2 shows the top 10 journals with the highest number of articles published during the period 1990 to 2017. The journal with the highest number of articles published was *Journal of Agricultural and Food Chemistry*, with a total of 606 documents that represent 1.36% of the total published documents. The next journal was *Food Chemistry* with a total of 447, and the third was *Coffee Science* with 390. Furthermore, table 2 also shows, the journal appears in the first place, its average growth rate (AGR) during the period: 2016 - 2017 was negative. So, it had a decrease in the produced articles. Instead, the second journal had an AGR positive in the same period. *Coffee science* has been publishing a constant number of articles, leading it to occupy the third position, its Hirsch index (h-index) is still small with only 11.

Table 2: Coffee topic highest number articles top 10 journals.

N	Journal	Total	AGR	h-ind
1	Journal of Agricultural and Food Chemistry	606	-13.0	81
2	Food Chemistry	447	10.5	59
3	Coffee Science	390	-0.5	11
4	Plos One	322	-10.5	34
5	Food Research International	246	1.5	33
6	Ciencia e Agrotecnologia	232	-3.0	16
7	Pesquisa Agropecuária Brasileira	188	-4.5	23
8	American Journal of Clinical Nutrition	169	-4.5	62
9	Agroforestry Systems	154	2.0	31
10	American Journal of Epidemiology	142	-3.0	66

Journal number position (N), total number of publications (Total), average growth rate from the last period studied (2016 - 2017), and h-index (h-ind).

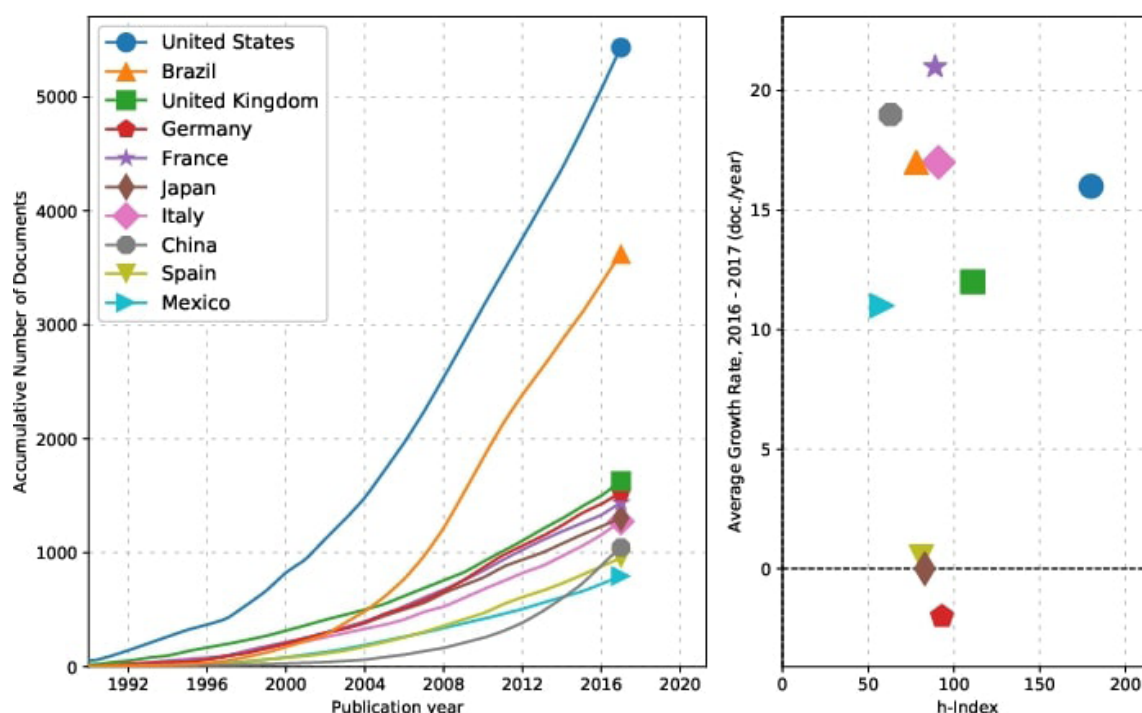
Countries with the highest number of articles are shown in Figure 1. The United States (USA) with 5440 and Brazil with 3628, accounts for 20.3% of the total number of articles published due to research on business value, improving and expanding the coffee production, compounds, composition, and impacts on human health. These countries formed the core of scientific production in this field and they present a rising curve in the quantity of document since 2004.

Moreover, the USA was the country with the highest h-index with 180, followed by the United Kingdom with 111, Germany with 93, Italy with 91 and France with 89. Despite Brazil holding the second in the articles published ranking, its AGR is only 78.

Meanwhile, 53 institutions have published more than fifty articles. Figure 2 shows the ten institutions with the highest number of articles published. The institution with the highest number of articles published on this research field was *Universidade Federal de Lavras*, with a total of 418 articles. Also, the average growth rate (AGR) during the period 2016 - 2017 was positive for the first and third institution with 5.5 and 4.5 respectively. The *Univ Fed Viscosa*, Brazil with a total of 339 articles had a decrease of -7 in the number of articles published. The CIRAD institution from France with 135 articles is the highest AGR with 7.0 during this period. The institution's country was extracted from authors affiliations. According to the institutions rank, Brazil is the country with the highest total number of articles published, where, five from the first ten institutions belong to this country, followed by the United States and France.

3.1 Author Keywords Analysis

The author keywords in research articles define the field, subfield, topic, research issue, etc. that are covered by the article. Besides, other researchers can find papers when they are searching for the topic. The most electronic search engines, databases, or journal websites use author keywords to identify relevant papers and to show the papers to interested readers. Here, we analyzed the first 400 author keywords according to the best h-index for different research categories related to coffee. The author's keywords were classified by type, according to their relationship with the following macro topics, compounds, agronomy, product, economy, health, and generic words.

**Figure 1:** Ranking the most productive countries on Coffee.

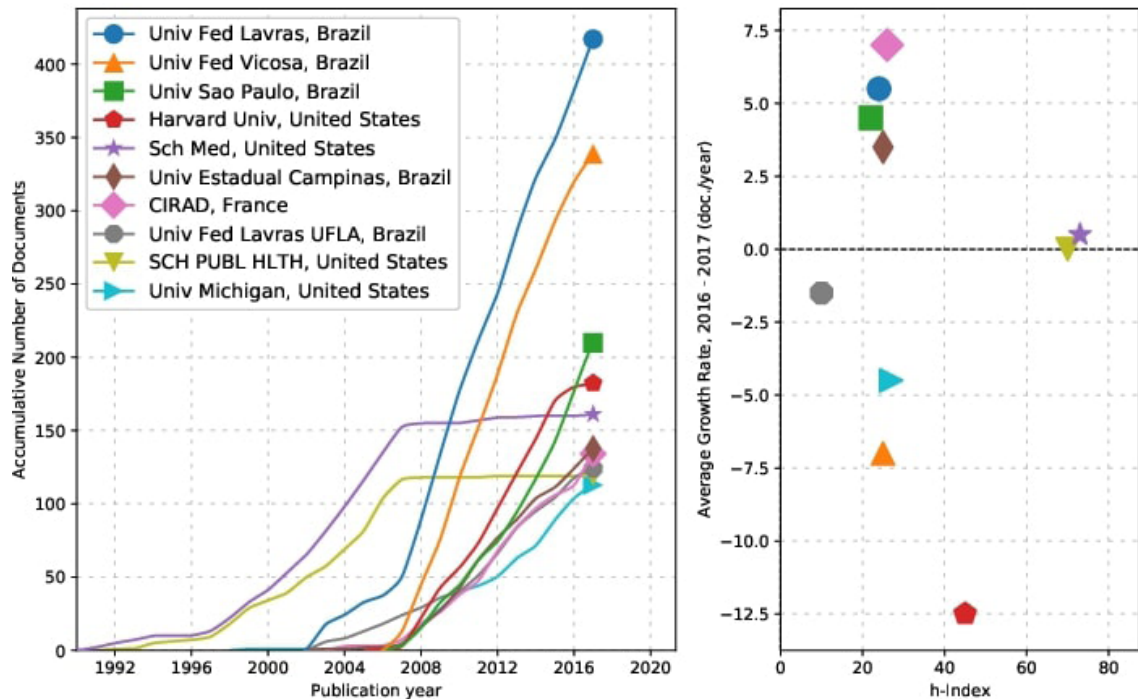


Figure 2: Ranking the most productive institutions in the country on coffee research.

Figure 3 shows the percentage of participation of each of these subgroups in the sample. Agronomy, health, and product stand out with the greatest participation, according to this they were analyzed separately. In addition, the importance of these subgroups lies in the incremental trend of the scientific production of coffee growing in these fields.

The words with semantic relationship “agronomy” were divided into four categories: plant health, coffee production system, coffee varieties, and other terms. Thus, a constant growth can be observed in relation to the publications that contain among its keywords, at least one word related to “agronomy”. Figure 4 highlights the constant growth of publications related to production systems and coffee varieties.

In production system category, it is worth highlighting the most cited article, 366 times, this discusses the variety *Coffea arabica* and the pollination with bees for production (Klein; Steffan-Dewenter; Tschardtke, 2003), in addition, other topics related to this word are *genetic diversity* (Anthony et al. 2002; Anthony et al., 2001; Hecimovic et al., 2011), characteristics of the cultivar (Anthony et al., 2002; Noir et al., 2001; Quiroz-Figueroa et al., 2002) and *coffee bean* (Knopp; Bytof; Selmar, 2006; Bagdonaitė; Derler; Murkovic, 2008; Bytof et al., 2005). As well as, one of the most cited words is *agroforestry* relating to biodiversity and environmental management with coffee production (Perfecto; Vandermeer, 2008; Tschardtke et al., 2008; Perfecto et al., 2005).

Health category has a similar proportion of publications related to the harmful effects of coffee and its derivatives, in addition to its beneficial effects. From the list of words, the

most used by the authors during the period analyzed was *diet* (Johnston; Clifford; Morgan, 2003; Lutsey; Steffen; Stevens, 2008; Hanhineva et al., 2010; Calder et al., 2011; Peters et al., 1992), with an average number of 18 documents per year, *nutrition* (Hulshof et al., 2003; Graham et al., 1991; Zeegers et al., 2004; Graham et al., 1992; Baghurst et al., 1991), *lifestyles* (Nygard et al., 1998; Hassan; Killick, 2004; Matsumoto et al., 2003; El-Khairi et al., 1999), risk factors (Lindsay et al., 2002; Chang et al., 1997; Gomaa et al., 2008; Rasmussen, 1993; Refsum et al., 2006; Schulze et al., 2005) and mainly diseases such as Parkinson (Higdon; Frei, 2006a; Chen et al., 2001; Hu et al., 2007; Morano et al., 1994; Tan et al., 2003), obesity (Calder et al., 2011; Murase et al., 2011; Kamycheva; Joakimsen; Jorde, 2003; Dennis; Flack; Davy, 2009), diabetes (Scalbert et al., 2005; Fraser, 1999; Greenberg; Boozer; Geliebter, 2006; Mcglynn; Petrick; London, 2015; Montonen et al., 2005; Rosengren et al., 2004), hypertension (Suzuki et al., 2006; Jee et al., 1999; Hodgson et al., 1999; Watanabe et al., 2006; Habauzit; Morand, 2012), cancer (Somoza, 2005; Langner; Rzeski, 2014; Langner et al., 2013; Gasscht; Dicato; Diederich, 2015; Fraser, 1999; Weisburger; Chung, 2002; Ghadirian; Lynch; Krewski, 2003) and cardiovascular diseases (Dam, 2008; Heidemann et al., 2009; Grosso et al., 2017; Grosso et al., 2016; Ferrari et al., 2016).

The words with semantic relationship “product” correspond to the set of words related to post-harvest coffee processing, which were divided into four categories: Coffee characteristics, product presentation, comparison between similar drinks and manufacturing processes. The features

category has had great growth in publications in recent years, reaching more than 100 publications in 2017, 43% of the subsamples analyzed. It emphasizes words such as *food* (Nicoli et al., 1997; Svensson et al., 2003; Jorgensen, 1998), Beverages (Pellegrini et al., 2003; Mattila; Hellstrom; Torronen, 2006; Richelle; Tavazzi; Offord, 2001) and Aroma (Yeretzian et al., 2002; Sunarharum; Williams; Smyth, 2014). In the presentation the most highlights words are *espresso coffee* (Mussatto et al., 2011; Corti et al., 2002; Parras et al., 2007), instant coffee (Kilmartin; Hsu, 2003; Charlton; Farrington; Brereton, 2002; Briandet; Kemsley; Wilson, 1996), and coffee pulp (Prata; Oliveira, 2007; Avallone et al., 2000). Next, coffee is mainly compared to products such as tea (Nawrot et al., 2003; Popkin et al., 2006; Hurrell; Reddy; Cook, 1999; Natella et al., 2002), wine (Svilaas et al., 2004;

Valls-Pedret et al., 2012; Ferrari; Torres, 2003) and cocoa (Ferrari; Torres, 2003; Morales; Somoza; Fogliano, 2012; Moco et al., 2012).

Finally, The main manufacturing processes are *roasting* (Castillo; Ames; Gordon, 2002; Nunes; Coimbra, 2001; Nunes; Coimbra, 2007; Yeretzian et al., 2002), drying (Andriot; Quere; Guichard, 2004; Fadai et al., 2017; Marques et al., 2008) and fermentation (Lima; Vieira; Martins, 2008; Murthy; Naidu, 2012b; Silva et al., 2000).

In the generic category, there are words that cannot be classified in the categories defined by this study because they can belong to all categories or none of them, some of the words found in this category are analysis, quality meta-analysis, review, case-control study, systematic review, validation among other.

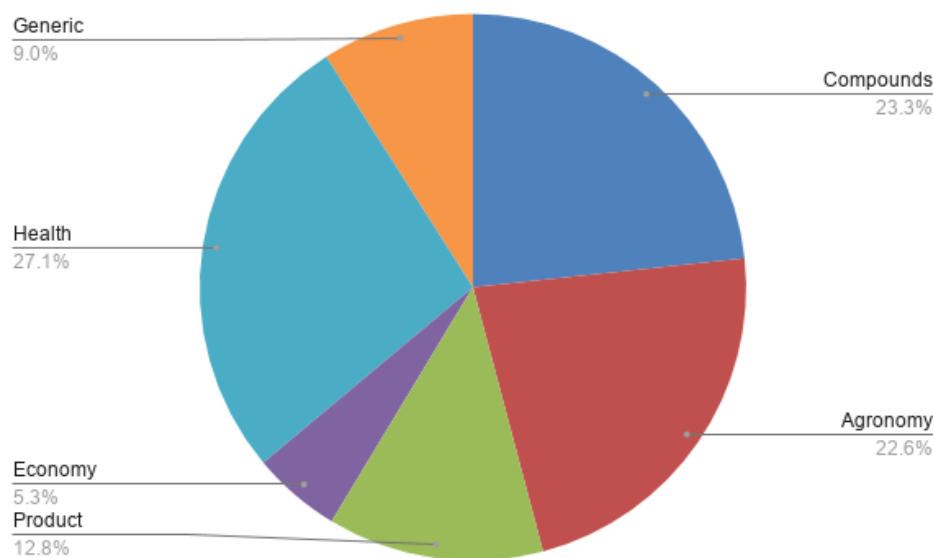


Figure 3: Author keywords classification.

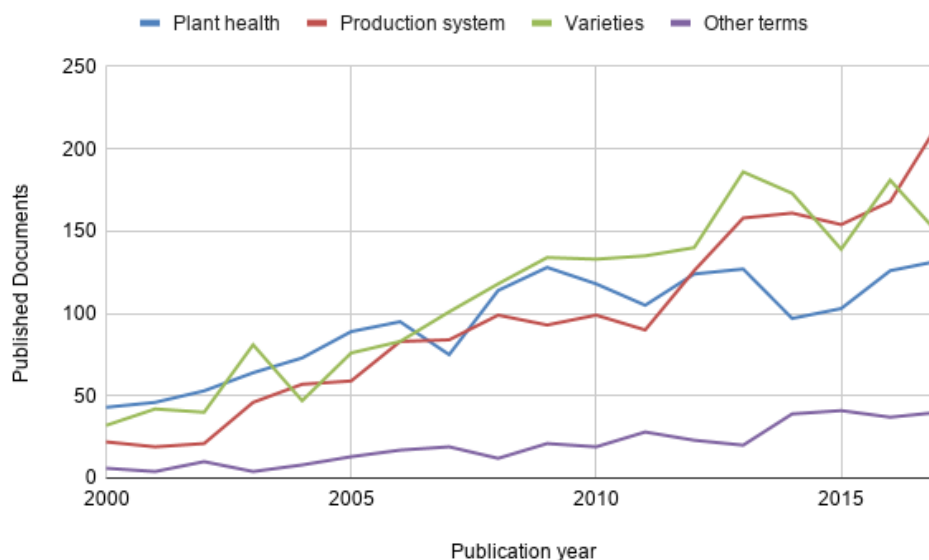


Figure 4: Agronomy classification.

4 CONCLUSIONS

This paper presents a bibliometric analysis of coffee research. The main goal of this study is to identify and classify the systematically the scholarly articles from 1990 to 2017, integrating subject categories of journals, countries, and author keywords. The results show a remarkable grown in articles per year, from 184 and 118 articles published from 1990 to 2068 and 2046 in 2017 for Scopus and WoS respectively.

Coffee research has been a challenge for both consumers and producers' countries. The United States and Brazil are the principal participants in this research field, this due to business value, the need for improving and expanding the coffee production, to know the compounds, composition, and impacts on human health

In the analysis of the author's keywords, Caffeine is the component with the most articles published in the period studied, they focus on the relationship with different diseases, as well as the chemical composition. In the agronomy category, the problems related to the production system and coffee varieties are the fastest growing in recent years.

However, this analysis is only an approach that might be complemented by a more in-depth analysis. The results obtained to give a theoretical point of view, state of the art on the subject could be mapped, and gaps in the scientific research could be easily identified. This analysis bibliometric intends to be a reference for future works in the development of coffee analysis on topics such as the risks for human health, some kinds of cancer or even study depth specific topics that we have presented.

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Dataset. The dataset is available on: https://drive.google.com/drive/folders/1Ib_8oifc46jvA9Qe8_lwcmM9qeg-l42f?usp=sharing.

ScientoPy. ScientoPy is available on: <https://github.com/jpruiz84/ScientoPy>.

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