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## What have been highly pointed in bread and sourdough researches: using bibliometric analysis as a powerful tool

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### ABSTRACT

This study provided the opportunity to create a coherent general perspective towards research trends and basic studies in the literature, especially about “bread” and “sourdough”. The objective of this study is to analyze the evolution of trends in research topics in different countries and across the years (from 1989 to March 2021) in the literature on bread and sourdough using a term map analysis. In this regard, the present study was designed to reveal the hot topics. A total of 338 scientific papers were retrieved from the Web of Science (WOS) between 1989 and March 2021. VOSviewer software program was used to visualize these articles. 275 of these 338 articles consist of documents written in the field of “Food Science Technology”. The author of the most articles was Gobbetti M. It was found out that the most contributing publication to the field was the article entitled “Impact of sourdough on the texture of bread”. Italy stands out in studies compared to other countries, with the most published author is Italian. It was observed that studies on bread and yeast increased over the years with the advancement of technology and that different studies were carried out on bread and sourdough.

## 1. Introduction

Bread, which provides the majority of daily calories, has an important place in food consumption as it is an essential nutrient and a good source of energy (Menteş et al., 2004). Bread is a basic food item obtained by mixing and kneading wheat flour, salt, water and yeast in certain proportions, shaping it according to its technique and cooking the dough after a certain fermentation period (Elgün & Ertugay, 2002). Sourdough is a product that has been used for 5000 years and is obtained by fermenting a mixture of wheat flour and water with lactic acid bacteria (LAB) and yeasts (Vogel et al., 2011). Traditional breads are still produced using sourdough today. The use of sourdough as a form of leavening is one of the oldest biotechnological processes in foods (Röcken & Voysey, 1995). Its main function is to ferment the piece of dough to obtain a more gaseous dough. In recent years, the demand for traditional sourdough bread, which is healthier, tastier, and more natural, has increased (Brummer & Lorenz, 1991).

Current research also emphasizes how the perception of bread consumption is changing. Many studies have also focused on the possibility of adding functional ingredients to

improve and increase the original nutritional value of bread (Althwab et al., 2021; Weng et al., 2021; Sridhar et al., 2021). According to Althwab et al. (2021), effects of incorporation of *Locusta migratoria* (LM) powder at different levels (0, 1, 2, 3, 4 and 5%) on nutritional, qualitative and sensory properties of baked breads were investigated. It is concluded that the addition of LM powder improves the nutritional and sensorial properties of the produced bread when the wheat flour is substituted with 1–4% of LM powder. Yeast and sourdough, which are the indispensable parts of bread making, are important criteria for bread quality (Röcken & Voysey, 1995).

Thanks to bibliometric analysis, it has been used as a quantitative approach to systematically classify published articles in many aspects such as journal title, article themes, publication year, author names, institutions and countries, author citations, type of collaboration, and type of article. Bibliometric analysis is used in the evaluation of academic studies in scientific disciplines through its above-mentioned features (Okumus et al., 2018; Rey-Marti et al., 2016).

Vosviewer program has been widely employed for a quite number of field studies such as Food Science & Technology (Paunkov et al., 2019, Kamdem et al., 2019), Agriculture, (Kulak et al., 2019), Zoology (Freire & Nicol, 2019),

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Environmental Sciences & Ecology (Liao et al., 2018). At the same time, when examined in general, it was mostly used in the subjects of Business Economics, Environmental Sciences Ecology, Computer Science, Information Science Library Science.

Based on previous bibliometric analyses (Kim & McMillan, 2008), these two objectives will be concretized in three research questions (RQ).

RQ1. Which authors have obtained the highest visibility and impact in the field of bread and sourdough? That is, who are the most cited authors?

RQ2. Which journals have obtained the highest visibility and impact in the field of bread and sourdough? That is, which are the most cited journals?

RQ3. For bread and sourdough studies, how long way we have come and how much further?

The answers to these questions are important for guiding research or for designing more comprehensive new studies. The present article provides a map showing the spread of scientific knowledge about bread and sourdough throughout the world. Despite productive quantitative research on the effect of sourdough on bread, none of these have attempted to visualize progress and provide a keyword analysis of the "bread" and "sourdough" interaction knowledge domain. The objective of this study is to analyse the trends in the literature on bread and sourdough and to reveal the evolution of research topics over the years and in different countries through a term map analysis. The term mapping approach allows determining trends in scientific publications and the number of publications for journals, countries, research institutes; provides an overview of the main research areas, relationships and developments over time; and identifies the most cited terms. In summary, thanks to the term mapping approach, a compilation was made to answer the questions such as which subjects were studied together with the subject of bread and sourdough, which authors came to the fore in which studies, which countries worked extensively on bread and sourdough subjects. Therefore, the objective was to carry out a mixed review, adopting a bibliometric analysis together with a literature review, to present information from the research and observe future trends for sourdough and bread.

## 2. Materials and methods

### 2.1. Database search

Since the Web of Science (WOS) is a database which includes "Science Citation Index (SCI)", "Social Science Citation Index (SSCI)" and "Art and Humanities Citation Index (A & HCI)", it provides the opportunity to reach publications worldwide (Deis & Goodman, 2005). Besides, "Conference Proceedings Citation Index- Science (CPCI-S)", "Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH)", "Book Citation Index- Science (BKCI-S)", "Book Citation Index- Social Sciences & Humanities (BKCI-SSH)" and "Emerging Sources Citation Index (ESCI)" include scientific citation indexes.

In this study, when we determine the search criteria in the form of TITLE: (bread) AND TITLE: (sourdough) Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A & HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI using the Web of Science (WOS) 338 articles emerge in 31 March 2021. The documents published during the period of 1989-2021 were included. After assessment literature in the title and abstract of all documents, duplicated articles, errata and undefined

documents were excluded. The research is limited to publications written in English (Article, Proceedings Paper, Review, Meeting Abstract, Book Chapter, Book Review, Early Access, Editorial Material, Correction, News Item). VOSviewer software program was used to visualize these articles. With the help of VOSviewer software, the literature was illustrated in a mapped way. Unlike other web-based programs used for mapping, VOSviewer places special emphasis on graphic presentation. There are two aspects of bibliometric mapping, namely the construction of bibliometric maps and their graphical representation. The functionality of VOSviewer gains importance in terms of being useful in viewing and interpreting large bibliometric maps easily (Karagöz et al., 2020).

### 2.2. Bibliometric mapping and clustering

The concept of bibliometrics was put forward by "Alan Pritchard" in 1969 and means "the application of mathematics and statistical methods to shed light on the processes and course of these resources by counting and analyzing various aspects of written sources" (Lawani, 1981). In order to perform bibliometric analysis and visualize the results, VOSviewer (software version 1.6.16) software, which does not require any fee and is open to everyone, was used. VOSviewer is a scientific mapping program designed for the visual representation of bibliometric networks. The program, which was mainly designed to analyze bibliometric networks, focuses on the formal representation of networks (Van Eck & Waltman, 2009). The study aimed to reveal documents, sources, authors, institutions and countries, which stand out in publications including the words "bread" and "sourdough" in their titles, with "Co-authorship, Co-occurrence and Citation" techniques.

Bibliographic records were made with quantitative explanation. At the point of research on bread and sourdough, the most collaborative authors and countries, the most used keywords, and the most cited documents, sources, authors and countries about bread and sourdough were determined as a result of bibliometric analysis. In addition, the maps of the publications were created using color intensities depending on the number of publications. The number of publications was counted through the consideration of all co-authors of an article.

## 3. Results and Discussion

### 3.1. Bread and sourdough publication trends

This study aims to make bibliometric analysis of the results obtained from the data in the Web of Science (WOS), which is an international database, with tables and figures. The number of studies on "bread and sourdough" in the period between 1989 and in March 2021 in the Web of Science database is 338. The analysis of the studies by years is shown in Table 1.

Hansen et al. (1989) article entitled "Flavor Of Sourdough Rye Bread Crumb" and the aroma compounds in rye breadcrumbs made from sourdoughs fermented with starter cultures (three heterofermentative and two homofermentative) were compared with those in rye breads chemically acidified with lactic acid and lactic/acetic acid. From 1989 to 1990, there were no regular studies on this issue every year, and the number of studies was limited to 1. Since 2003, there has been an increase in the number of studies on "bread and

sourdough". The year with the most studies is 2020 with 50 studies.

**Table 1.** Distribution of studies conducted on "bread and sourdough" in the Web of Science (WOS) database by years.

Years	Number of Studies	Years	Number of Studies	Years	Number of Studies
1982	1	2000	2	2012	18
1984	1	2001	1	2013	11
1988	1	2002	3	2014	18
1989	1	2003	3	2015	20
1990	1	2004	2	2016	26
1991	1	2005	7	2017	27
1994	2	2006	7	2018	23
1995	1	2007	9	2019	37
1996	2	2008	12	2020	50
1997	1	2009	9	2021	5
1998	1	2010	15	-	-
1999	1	2011	19	-	-

With the development of technology, more detailed studies have begun to show differences in fields related to bread and sourdough. Especially when studies conducted between 2020 and 2021 are examined, issues such as shelf life, aromatic profiles and sensory properties, nutritional value and health benefits (Hajinia et al., 2020; Plessas, 2021), carbohydrates (Stern et al., 2021), *Lactic acid bacteria*, fructans, irritable bowel syndrome, texture profile, FODMAPs (Hajinia et al., 2020; Fraberger et al., 2020; Menezes et al., 2021; Jagelaviciute & Cizeikiene, 2021), fermentation (Hajinia et al., 2020; Luca et al., 2021; Galoburda et al., 2020), gluten free bread (Jagelaviciute & Cizeikiene, 2021), innovative food and antioxidant activity (Hajinia et al., 2020; Nissen et al., 2020), bread crumbs and crust (Galoburda et al., 2020) were examined in studies on bread and sourdough. This situation shows that there has been more interest in the subject of "bread and sourdough". Also, this rising trend is an indication of the fact that the research interest is in the use of sourdough as a bioactive compound to produce functional food and that transformation technologies are developed and consequently allow better use of by-products.

When the studies on the WOS are listed, articles are in the first place (N=302), whereas proceedings papers are in the second place (N=20). Then, reviews ranked 3<sup>rd</sup> (N=9), early access papers (N=4) ranked 4<sup>th</sup>, and book chapters ranked 5<sup>th</sup> (N=3), respectively. In addition, out of the 338 published studies, 7.4% were in *LWT Food Science and Technology* with N = 25; 6.5% were in *Food Chemistry* with N = 21; 5.6% were in *European Food Research and Technology* with N = 19; and 5.6% were in *International Journal of Food Microbiology* with N = 19. The publisher that publishes the most according to the given rates is LWT - Food Science and Technology magazine. LWT - Food Science and Technology is an international journal that publishes innovative articles in the fields of food chemistry, biochemistry, microbiology, technology and nutrition. The studies described are innovative either in approach or in methods used. With many studies being done in this journal, it also enables international information access. Thanks to the above-mentioned features, it has enabled many authors to choose this journal and it pioneers other journals on bread and sourdough.

When the studies on bread and sourdough were examined in the WOS database, a total of 1020 authors were found. The first 8 authors who conducted the most research on this subject are shown in Table 2. At this point, "Gobetti M." is the

first author to have conducted the most research on bread and sourdough. This author is followed by "Arendt E.K." and "Rizzello C.G." with 20 studies. Then, "De Angelis M." and "Gänzle M.G.", who conducted 12 studies, comes next.

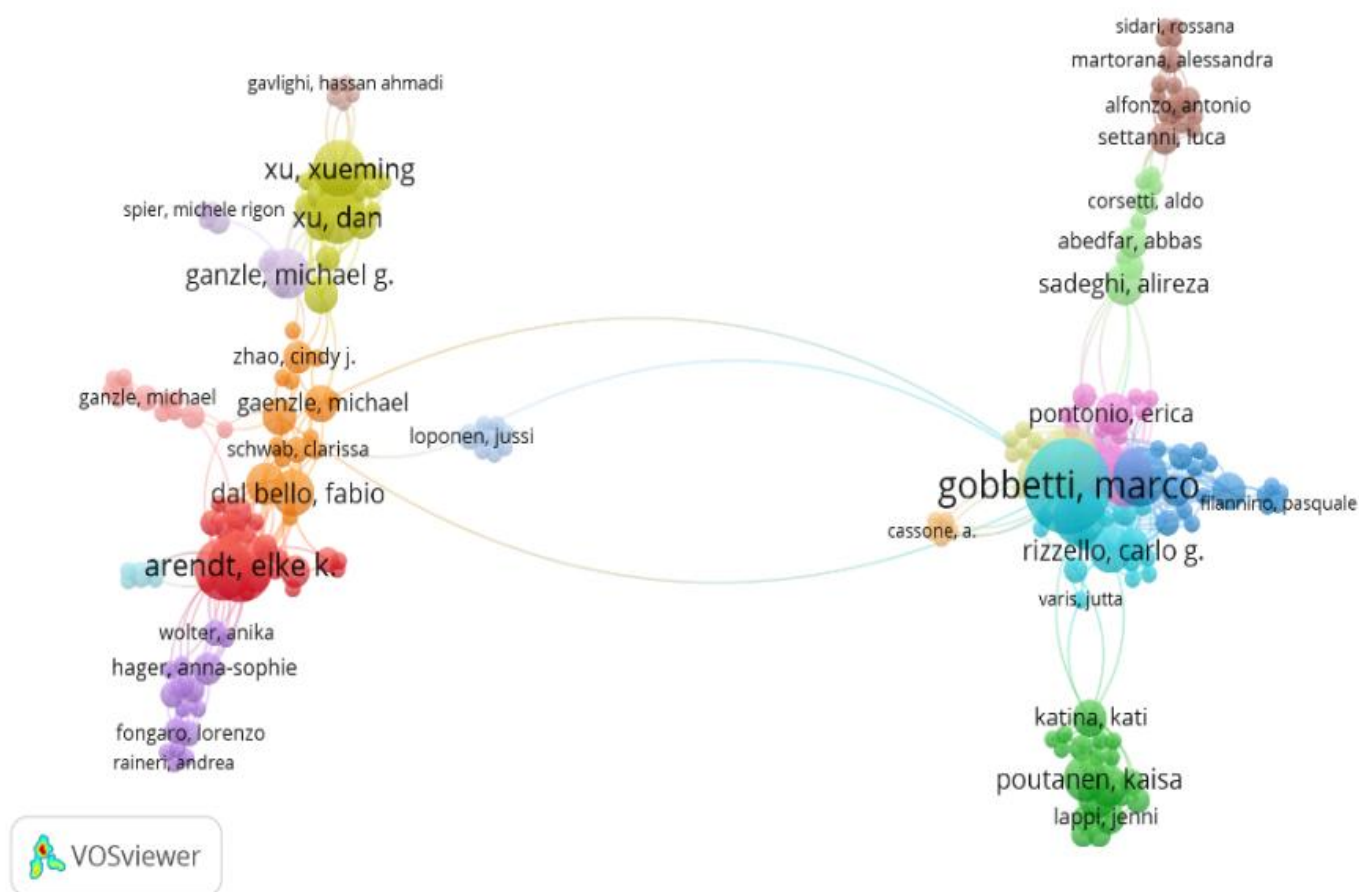
**Table 2.** Distribution of studies on bread and sourdough by authors

Author(a)	Number of Publications
Gobbetti M.	28
Arendt E.K.	20
Rizzello C.G.	20
De Angelis M.	12
Gänzle M.G.	12
Di Cagno R.	11
Plessas S.	11
Zannini E.	11

In the program (VOSviewer), when the minimum number of documents and the minimum citations of the author are selected as 1, 997 of 1135 authors in total meet the threshold value. Information on the collaborating authors is visualized in Figure 1, and the authors collaborating on research on bread and sourdough are seen in 17 clusters. The color of each cluster is shown in different colors. The blue color represented by the largest ring indicates the most collaborative authors. The most collaborative writers are "Marco Gobetti, Rosanna Coda, Jutta Varis and Carlo Giuseppe Rizzello".

The main function of citations is to establish a link between the cited person and the cited document. The main role of citations is to introduce previous research. In addition, other sources are cited for reasons such as evaluating relevant studies, showing evidence, defining the method, showing that they are aware of the relevant publications, and providing broader reading (Al & Tonta, 2004). Table 3 shows the distribution of the authors who conducted research on bread and sourdough according to their most cited characteristics, publication names, which source they published, years of publication, and number of citations. The most cited work in this study is the article entitled in 2007 "Impact of Sourdough on the Texture of Bread" which was written by "Arendt, Elke K.; Ryan, Liam AM; Dal Bello, Fabio" and published in *Food Microbiology*. The main reason why this study is at the forefront is that it is thought to have a wide range about the subject of bread and sourdough. Many subjects such as important sourdough technologies, the effect of using sourdough in bread on nutrition, the importance and roles of lactic acid bacteria in sourdough and bread, the ecology of sourdough, and the variety of cereals on sourdough have been mentioned. It has shed light on many studies due to the mention of the above-mentioned issues. Moreover, the studies presented in this review show that the addition of sourdough has positive effects on bread technology. Recently, sourdough has been successfully applied to improve the quality of gluten-free bread. Also, the proteolytic activities of LAB show great potential in reducing gluten contamination in gluten-free recipes. In conclusion, the studies presented in this review show that the addition of sourdough has positive effects on the technological, nutritional and functional properties of bread (Papadimitriou et al., 2019).

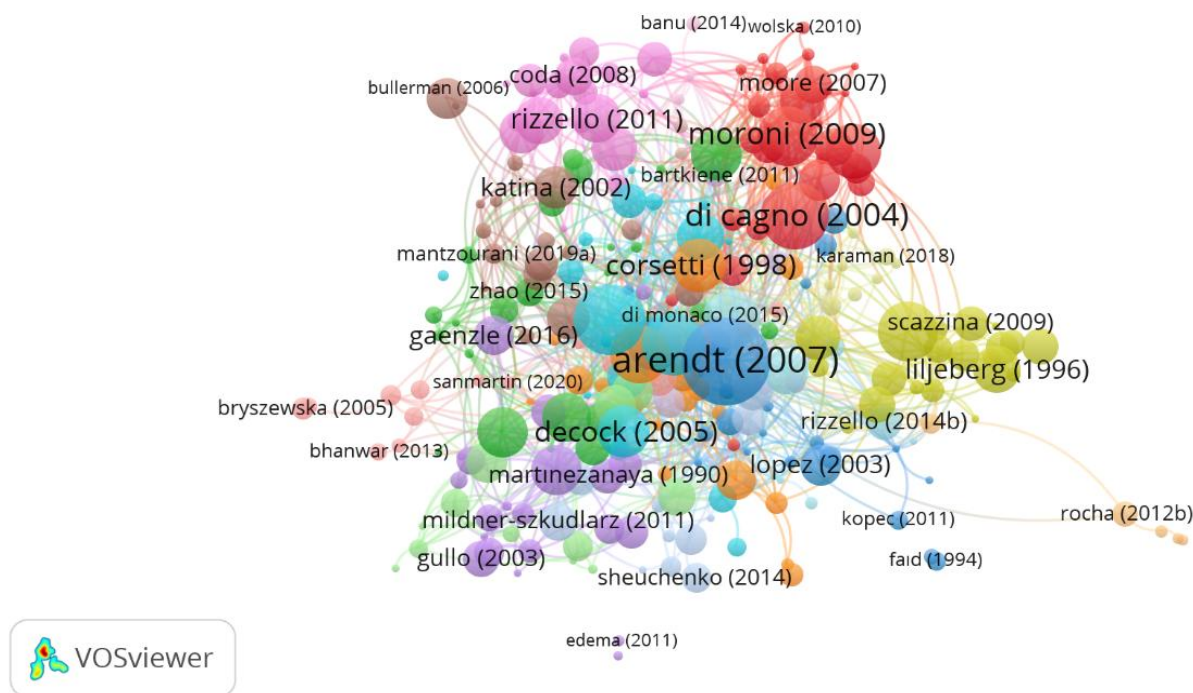
Information on the most cited documents in the studies on bread and sourdough are visualized in Figure 2, and the cited documents are seen in 18 clusters. At this point, the most cited document belongs to "Arendt, Elke K." (2007) with 321 citations in blue. Also in 2019, it received the most citations (N = 13.54%) with 44 citations, and more than 50% of the citations received in the last 5 years were received in the same



**Figure 1.** Most collaborating authors in academic studies on bread and sourdough. Different colors represent authors belonging to different clusters.

**Table 3.** Distribution of authors working on bread and sourdough by citations.

Publication Name	Author(s)	Source	Publication Year	Citation Numbers
“Impact of sourdough on the texture of bread”	Arendt, Elke K.; Ryan, Liam A. M.; Dal Bello, Fabio	Food Microbiology Volume: 24 Issue: 2 Special Issue: SI Pages: 165-174	2007	321
“Contribution of sourdough lactobacilli, yeast, and cereal enzymes to the generation of amino acids in dough relevant for bread flavor”	Thiele, C; Ganzle, MG; Vogel, RF	Cereal Chemistry Volume:79 Issue:1 Pages: 45-51	2002	211
“Sourdough bread made from wheat and nontoxic flours and started with selected lactobacilli is tolerated in celiac sprue patients”	Di Cagno, R; De Angelis, M; Auricchio, S; <i>et al.</i>	Applied and Environmental Microbiology Volume:70 Issue: 2 Pages: 1088-1096	2004	192
“Proteolysis in sourdough fermentations: mechanisms and potential for improved bread quality”	Gänzle, Michael G.; Loponen, Jussi; Gobbetti, Marco	Trends in Food science & Technology Volume: 19 Issue:10 Pages: 513-521	2008	168
“Sourdough Fermentation Or Addition Of Organic-Acids Or Corresponding Salts To Bread Improves Nutritional Properties Of Starch In Healthy Humans”	Liljeberg, Hgm; Lonner CH; Bjorck, Ime	Journal of Nutrition Volume: 125 Issue: 6 Pages: 1503-1511	1995	151



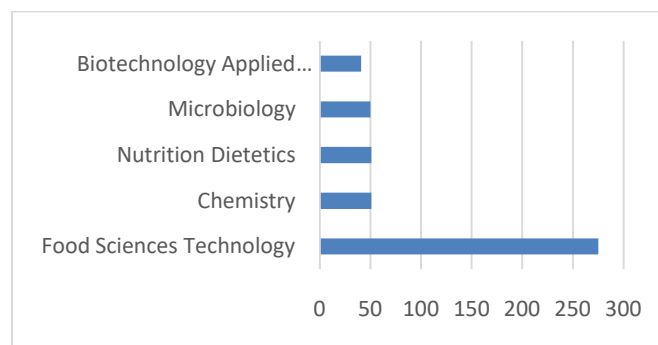
**Figure 2** Network map of the most cited documents on bread and sourdough. Different colors represent cited documents belonging to different clusters.

year. The second most cited author is Thiele et al., (2002) “Contribution of sourdough lactobacilli, yeast, and cereal enzymes to the generation of amino acids in dough relevant for bread flavor” in the light blue cluster with 211 citations. Thiele et al., (2002) determined the effect of acidification, addition of DTT, and sourdough fermentation on amino acid levels in dough. The results showed that the amino acid levels in wheat doughs depended mainly on the pH level of the dough, the fermentation time, and the consumption of amino acids by the fermentative microflora. It was demonstrated that increased levels of amino acids in doughs improved bread flavor. Furthermore, microbial formation of ornithine specifically enhanced the roasty note of bread crust odor (Thiele et al., 2002).

Figure 4 shows the top 5 field where bread and sourdough topics are studied the most. Especially in the field of Food Science Technology, the most contribution was provided and studies in this field constitute 81.36% of all fields. The main reason for this is that bread and sourdough, which have been the main food sources from the past to the present, are one of the indispensable fields of food technology.

In the program (VOSviewer), when the minimum number of documents and the minimum number of citations are selected as 1, 48 of 51 countries in total meet the threshold value. In the studies on bread and sourdough, the information on the countries cooperating the most is visualized in Figure 3, and these countries are seen in 10 clusters. The countries in each cluster also have connections with countries in different clusters. Turkey in the light blue cluster cooperates with the USA in the orange cluster. USA in the orange cluster cooperates with China in the green cluster. The reason for this is that American researchers and researchers in China have joint studies. For example, in 2009, American Rayas-Duarte Patricia worked with Chinese researchers on "Spontaneous sourdough processing of Chinese Northern-style steamed breads and their volatile compounds" (Kim et al., 2009). The country with the most cooperation is Italy which is in the red cluster. Although Italy has only one cluster, it has 14

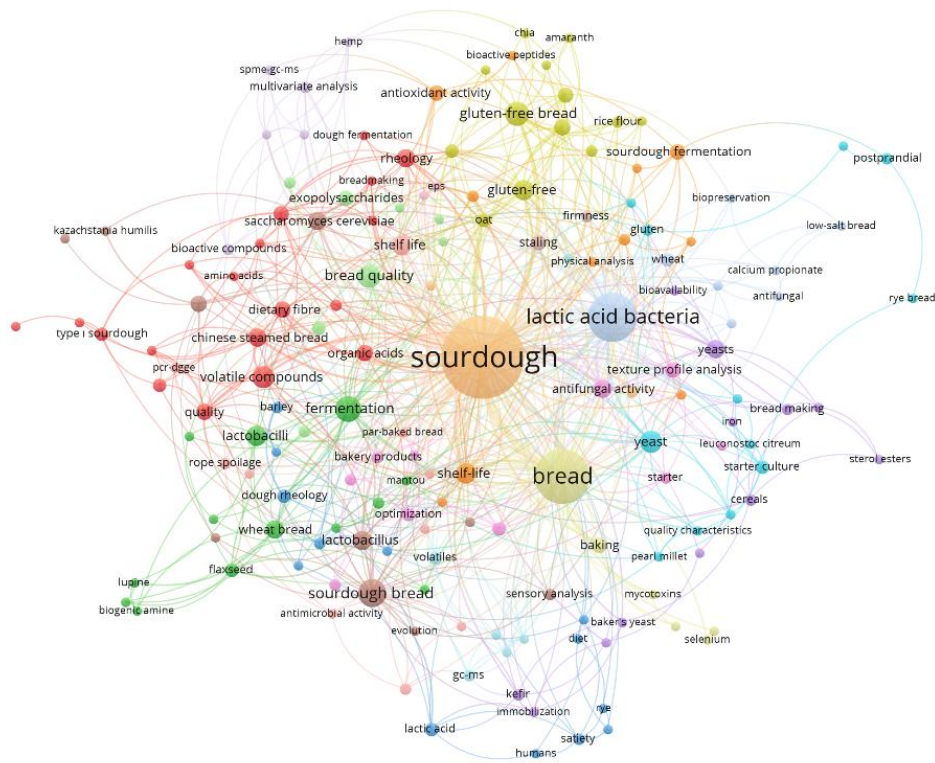
connections. Italy cooperates with many countries such as Finland, Brazil, Canada, China, Ireland and Hungary. In particular, of the 338 studies, 78 (23.07%) were conducted by Italy and 35 (10.35%) by China. This list is followed by Ireland (7.4%), Canada (6.2%), USA (6.2%) and Turkey (5.9%), respectively.



**Figure 4.** Distribution of studies on bread and sourdough by fields.

### 3.2. Word evolution of bread and sourdough research titles

Keyword is a word or group of words that will briefly and concisely represent your writing in an article. Keywords are chosen based on the queries made by the users in the search engine. While the work done to search engines is indexed (saving to databases), it detects the keywords on your page and is included in the indexed keywords in the search results. Thus, when a person searches for a keyword in the article in search engines, the previously indexed article appears in the search results. Mapping based on text data in VOSviewer program was used to identify the most commonly used keywords in the studies on bread and sourdough. When the minimum use of the keyword in the program is selected as two, 164 of the 732 keywords in total meet the threshold value. According to Figure 5, the keywords are visualized in



**Figure 5.** Visual representation of keywords based on co-occurrence. Different colors represent the terms belonging to different clusters.

18 clusters. Different colors are given for each cluster in the program. While the distance between the colored clusters indicates the closeness of the words to each other, the words also show that the terms in the center of the grid graph have a wider term range compared to those around the graph. For that reason, the VOSviewer clustering algorithm provides a basis for the classification of the literature (Ünlü & Alp, 2019). For example, 16 clusters with the word “sourdough” are shown in light orange, and there is cooperation with almost all words in the keyword network (144 occurrences). In the first years of the studies, topics such as bread quality and different sourdough controls (Hansen et al., 1989; Martínez-Anaya et al., 1990), effect of sourdough fermentation on bread (Olms, 1988; Faid et al., 1994), and characterization of sourdough bread (Martínez-Anaya et al., 1990; Seibel & Brümmer, 1991; Faid et al., 1994) were investigated. Crowley et al. (2002) investigated the effect of various amounts of sourdough on the texture and grain properties of wheat bread and examined the effect of storage on these properties, and on the possible relationships between this texture and structural properties. It was revealed that the addition of sourdough to wheat bread had significant effects on the consistency and grain properties of the baked product (Crowley, 2002). Katina et al. (2002) aimed to determine the relationship between the antimicrobial properties of the starter cultures, and the pH and total titratable acid (TTA) values of sourdough and the amount of lactic acid and acetic acid formed in sourdough. They also investigated the relationship between rope spoilage and lactic acid. The results showed that efficient use of sourdough to prevent ropes from spoiling required a carefully controlled sourdough process in order to achieve the required level of acidity in wheat sour and bread (Katina et al., 2002). These studies show that many studies have been carried out on sourdough from the past to the present. The second most used word is “bread” which is shown in light green, 13 clusters and there are 64

occurrences. When studies on bread, especially in recent years, are examined, it is seen that different issues are examined. The main ones are a) the effects of different microorganisms on bread (Hajinia et al., 2020; Cizeikiene et al., 2020; Bockwoldt et al., 2021), b) bread production with low glycemic index (Sridhar et al., 2021) and low FODMAP (Menezes et al., 2021), c) gluten-free bread production (Jagelaviciute & Cizeikiene, 2021; Maidana et al., 2020), d) use of different ingredients as flour and their effect on bread (Jagelaviciute & Cizeikiene, 2021), and e) functional bread production as the common point of these studies. Jagelaviciute & Cizeikiene (2021) examined the effect of unconventional sourdough made with quinoa, chia, and hemp flour on the quality and acceptability of dough and gluten-free corn / rice bread. Chia, hemp and quinoa showed successful fermentation with *Lactobacillus sanfranciscensis*, and the non-traditional type of flour used for fermentation (chia, hemp, and quinoa) had an effect on sourdough and bread properties. Sidari et al. (2020) studied sourdough biodiversity and new bread making technology for sourdough bread making. A scientific approach to traditional sourdough bread making, which aims to improve the properties of bread, was proposed. Sourdough made using a multi-channel starter was found to have a phenolic content and antioxidant activity similar to traditional sourdoughs made with durum wheat studied in this study. All of these studies are included within the bread and sourdough clusters.

As explained above, many studies have been carried out on bread and sourdough from the past to the present, and studies on bread, which is an important source of food for people, will always continue to be important and continue with studies that shape the future. The third most used word is “lactic acid bacteria” which is light blue in color and there are 51 occurrences. When the studies on lactic acid bacteria were examined, it was found out that typical sourdough prokaryotes were the members of the LAB genus *Lactobacillus*, which are

necessarily homofermentative, and that *Lb.sanfranciscensis* (Catzeddu et al., 2006), *Lb. plantarum* and *Lb. brevis* were the most commonly isolated LAB strains (Hajinia et al., 2020; Trüper & Clari, 1997). The other LAB strains, including *Carnobacterium divergens* (*Lb. divergens*, *Lb. amylophilus*, *Lb. sake*, *Lb. acetotolerans*, *L. plantarum*, *Pediococcus pentosaceus* and *P. acidilactici*, and *Tetragenococcus halophilus* (*Pediococcus halophilus*), were isolated from sourdoughs (Gül et al., 2005; Huys et al., 2013; Minervini et al., 2014).

The fourth is “sourdough bread” which was used 17 times and is shown in brown, while the fifth most used word is “fermentation” which was used 15 times and is shown in green. In this analysis, “sourdough” is clearly a very important term and shows that it is an important resource for bread quality and functionality and is considered to be important in international research studies. The synergistic metabolic activities of the microorganisms produce acidification or souring, which influence the final character of the bread, notably the texture, increase shelf-life by reducing the mold growth during storage (Röcken & Voysey, 1995; Corsetti et al., 2000; Elsanhoty et al., 2017; Cizeikiene et al., 2020) and generate typical flavor components which yield typical sourdough sensory attributes (Gobbetti, 1998; Katina, 2005). Thanks to these features, the other important keywords are “shelf life”, “quality” and “yeast”, “texture profile analysis”, “*saccharomyces cerevisiae*”, “oat”. Keyword co-occurrence and clustering are important for a more accurate view of research areas. It shows how keywords are limited and common for documents analysed based on results (Kulak et al., 2019).

## 4. Conclusions

It is the first study to provide bibliometric analysis of global research trends in "bread and sourdough" studies over the period 1989-2021.

1. With this analysis, it is possible to state that 338 publications were published from 1989 to in March 2021.
2. The first publication was published in 1989 as a article and Hansen et al. (1989) obtained rye bread crumbs by using different types of sourdough yeast and examined the physical and chemical properties of the obtained breads.
3. Time-trend analysis did not show a steady increase in the annual growth of documents, but overall, the number of publications did. In addition, the number of articles published in 2005 and the following years has seen a much sharper increase. It peaked in 2019 (37 studies) and 2020 (50 studies).
4. Italian writer Gobbetti has done the most publications and studies. Therefore, Italy leads the way among the countries that publish the most. It can also be said that there is a bond between China and the USA because an American writer collaborates with Chinese writers.
5. In addition to the words bread and sourdough, the subject of lactic acid bacteria, which is an important structure for bread and sourdough, was the keyword that attracted the most attention.
6. The most studied field is Food Science Technology. Besides, sourdough, one of the most traditional biotechnology, has significant effects on the rheology, sensory, and shelf life properties of bakery products, especially bread. Some aspects of it, such as the potential to lower the glycaemic index, increase mineral bioavailability, and reduce gluten content, have been

substantially proven. Due to these features, a research field has emerged that has been continuously increasing from the past to the present day.

7. As a result of the bibliometric analysis carried out, different requirements may arise in the future regarding the above-mentioned issues or different technologies may be created for current situations. The results of bibliometric analyzes can be examined before new studies are carried out on bread and sourdough, and this study will, for that reason, be a guide for future studies.

## Author Contributions

All authors contributed equally to this work.

## Notes

The authors declare no competing financial interest

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