Bibliometric analysis of traceability in agri-food research

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Abstract. Traceability in agri-food has become an important aspect of consumer awareness that demand foods that are available, in good quality, healthy, and traceable in handling processes. This field has also become the focus of the study among the related scientists. We used bibliometric analysis to review the published traceability of agri-food papers. The analysis using a query from the Scopus website to see the importance of this field to research. Our web search covers publication from 1998 to 2018, and we found 67 articles published on this query, and 31 papers include the query using the keyword 'food safety'. The authors of these articles are mostly from developed countries. Although somewhat fluctuated, the number of documents tends to increase with time to indicate that this field is growing.

1. Introduction
Traceability of agri-food is defined as made up of two terms, the traceability and the agri-food. Traceability itself is the ability to identify the current or past position of a product and its history of distribution [1], [2]. Agri-food can be defined as food that is produced by agricultural activities. The traceability in the agri-food supply chain is essential due to the nature of agri-food products, which is perishable, non-uniform, bulky, seasonal, etc. A sound traceability system allows a product to be traced for its producer, location, processing, the material used, suppliers of the materials, and much other information. Traceability becomes critical requirements in food safety, halal food supply chain, and other vital issues related to social care and environmental consciousness.

The issue of traceability is vital in business and research. Traceability supports business owners to ensure the excellent condition of their products until receiving by the customers. Companies from various sectors have been trying to address this issue of traceability [3], and it is now a necessary aspect in agri-food management. A number of benefits can be derived from this implementation, viz. the customers are now more secure and confident as they are able to control the impact of commodity withdrawal [2], [4],[5]. Accidents due to consuming food frequently occurred, like the case of rockmelon, tomato, and apple juice. Traceability system allows the chain of the product to be traced to ensure food security aspect [6],[7]. In relation to people’s safety and health, OECD countries have demanded the industry to implement this tracing system to provide food security to their people. The regulations for this system are available in 21 OECD countries [8].
The development of traceability research in the agri-food system describes the complexity of each of its related sectors. Information about the procedure through which agri-food passes from one sector to another can be gathered. This information, in turn, will increase consumer trust. The obstacles to handling agri-food are numerous and complex. Many entities are involved in the agri-food supply chain, such as suppliers of fertilizers, pesticides, seeds, production equipment, and farmers or farmers group with some labors, and post-harvest processing manufacturers. Each entity has its potential sources of problems in the agri-food system, and some objectives that were often conflicting; one another thus increases the complexity of the matter [9]-[12]. Traceability is undoubtedly helpful whenever there are problems in the supply chain, so they can be traced entirely on what, why, where, when, who, and how they occurred.

Many approaches might be taken to address the problem of traceability in agri-food. One of them is through the research on the subject matter, including the implementation of the system in agri-food management [13]. Here we explored the Scopus database as the premier provider of any research platforms to provide the information about the researches that have been made regarding the traceability of agri-food until recently. The bibliometric method was chosen as a quantitative way that enables us to do structured literature review and cover all the previous research comprehensively [14] to see the trend of the topics based on year of publications, source, title, affiliation, subject area and document type.

2. Research Methods
Many scientific publications have been maximizing the use of scientific publications data in online providers and employed bibliometric methods to support their review, viz. [15],[16]. In this paper, we modified the bibliometric method of [9]. Four steps were employed, viz. journal selection, periods, article selection, and analysis. Journal selection was entirely conducted on the Scopus website. To get a considerable return to our query, two queries viz. (TITLE-ABS-KEY (traceability) AND TITLE-ABS-KEY (agri-food)) were used to find the publications with the title, abstract, and keywords stated by the phrase in the bracket. Initially, we searched the whole publications available in Scopus without a time frame. Our search showed that the earliest paper published was in 1998 and that there was an abrupt increase since 2009; therefore, we separated the time frame into two periods, viz. 1998-2009 and 2009-2018, to observe the trend on existing subject areas as well as the rising of new subject areas. We added “food safety” to the query viz. (TITLE-ABS-KEY (traceability) AND TITLE-ABS-KEY (agri-food) AND TITLE-ABS-KEY ("food safety")) and conducted the second search to the papers collected in the first search, to know how important the phrase ‘food safety’ to these papers. The collected data were analyzed using bibliometric indicators as provided by Scopus.

3. Results
Our query on “(TITLE-ABS-KEY (traceability) AND TITLE-ABS-KEY (agri-food))” at Scopus website resulted in 67 papers (Table 1). We accessed this website on August 7, 2018, and found that the first paper published was in 1998. From 1998 to 2008, there are only 15 papers published on this query. The highest number of published papers was in 2007 with, while during the year of 1999 until 2002 and 2004 there is no paper published on this query. During the period of 2009 – 2018, 52 papers are published, reached as high as nine papers in 2015 and the lower number was in 2013, 2014, and 2016 (Figure 1).

Table 1. The big five countries and publication sources that publish papers on ‘agri-food’ and ‘traceability’ query from 1998 through 2018.

| Country  | No. of Paper | Publication Source                  | No. of Paper |
|----------|--------------|-------------------------------------|--------------|
| Italy    | 17           | Italian Journal of Agronomy         | 3            |
| France   | 6            | 13th International Conference on Service Systems | 2            |
In Figure 1, although the number of publications is relatively fluctuated, but we see that there is an increasing trend in the number of publications. Based on this trend, the number of publications may increase in the future.

The number of covered subject areas is increased from 11 to 18 from the period of 1998-2009 to 2009-2018 (Table 2). Nine new subject areas are found from 2009 through 2018, they are; Art and Humanities, Biochemistry, Genetics and Molecular Biology, Chemical Engineering, Chemistry, Decision Sciences, Energy, Nursing, Psychology, and Physics and Astronomy. On the other hand, only two subject areas viz. Immunology and Microbiology, as well as Veterinary that are not covered by any papers during 2009-2018.

Developed countries, particularly European countries, publish most of the papers related to the query (Table 1). Furthermore, most of the papers viz. 17 papers or 25% of the total are written by Italian scientists. In contrast, the rest of the European scientists from countries like Germany, Greece, Spain, the United Kingdom, have only published five papers. The only country outside Europe to publish the same amount of paper with these four European countries is the United States. As Italy publishes most papers, so does the publication source in this country, viz. the Italian Journal of Agronomy, which published three papers. IOT summit 2018 held in Tuscany, Italy, add two more papers. The rest of the Italian papers are published by other sources of publications. Other country publications only issued two articles related to this query (Table 1).

There are 20 subject areas of publication cover by these 67 papers related to the traceability of agri-food From 1998 to 2018 (Table 2). The number of documents pertaining to different subject areas exceeds 67, since one paper may refer to one or more subject areas. The 15 articles published in 1998-2008 cover 25 subject areas, while the 52 papers published in 2009-2018 cover 123 subject areas. The “Agricultural and Biological Sciences” is the most covered area by the publications, viz. by 31
articles. The subject area of Engineering, Computer Sciences, and Business, Management and Accounting is covered by more than ten papers, viz. 18, 15, and 12 articles, respectively. The subject areas include “Art and Humanities, Chemical Engineering, Energy, Immunology and Microbiology, Psychology, Physics and Astronomy. While, Veterinary is the least areas covered by the papers, with only one paper on both periods (Table 2).

Table 2. Subject area covered by the published papers on ‘agri-food’ and ‘traceability’ query during the period of 1998-2008 and 2009-2018.

| Subject Area                           | Period          |
|----------------------------------------|-----------------|
|                                        | 1998 - 2008     | 2009 - 2018 |
| Agricultural and Biological Sciences   | 9               | 22          |
| Art and Humanities                     | -               | 1           |
| Biochemistry, Genetics, and Molecular Biology | -       | 4           |
| Business, Management and Accounting   | 2               | 10          |
| Chemical Engineering                   | -               | 1           |
| Chemistry                              | -               | 3           |
| Computer Sciences                      | 1               | 14          |
| Decision Sciences                      | -               | 9           |
| Economics, Econometrics and Finance   | 1               | 5           |
| Energy                                 | -               | 1           |
| Engineering                            | 5               | 13          |
| Environmental Sciences                 | 2               | 2           |
| Immunology and Microbiology            | 1               | -           |
| Mathematics                            | 1               | 1           |
| Medicine                               | 1               | 3           |
| Nursing                                | -               | 2           |
| Psychology                             | -               | 1           |
| Physics and Astronomy                  | -               | 1           |
| Social Sciences                        | 1               | 5           |
| Veterinary                              | 1               | -           |

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4. Discussion
The published papers on the query of “agri-food” and “traceability” from 1998 through 2018 increased in trend (Figure 1). They are relatively limited from 1998 through 2008 and become more occasions between 2009 and 2018. The raise is more than triple viz. 22% to 78%, to indicate that the studies related to this field are growing. The number of papers published yearly is relatively fluctuated as well (Figure 1).

The dominance of European countries to study and publish papers related to agri-food and its traceability (Table 2), resembles not only the thoughtfulness of the European researchers, but also the awareness of the consumers, and the mindfulness of the authority of these countries to the subject matter. The first publication on this topic is written by [17], the researchers from the United Kingdom, that captured the introduction of the traceability system in the Scottish agri-food industry for the increasing need to put it into practice due to food safety issue [17]. The main driving force of food safety awareness in Europe was the BSE (Bovine Spongiform Encephalopathy) crisis or Mad Cow
Disease that plagued the United Kingdom at the end of 1990s [18]. This disease led to the collapsing of the industry, the slaughtering of 3.3 million cattle, and £3.7 billion of estimated economic loss [19], but also human casualties due to Creutzfeldt-Jakob Disease (JD). This BSE variant attacked humans [20]. From the authoritative perspective, the European Commission was also very attentive with the release of EC General Food Law Regulation 178/2002, including the adjustment concerning matters like GMO, allergens, food hygiene that require the establishment of a traceability system for all food products [21].

Italy publishes most of the papers related to agri-food and its traceability (Table 1). Among the Italian universities that concern this subject matter by publishing more papers than others are the Politecnico di Torino, Università Degli Studi di Napoli Federico II, Università Degli Studi di Messina, and Università Degli Studi di Palermo. From the consumer's side, especially after the BSE crisis, Italian consumers demand more transparency in the food chain as well as more information on food quality aspects [22], that they regard traceability as an important factor for food security [23]. They are also more inclined to buy traceable and trackable products[24].

The subject areas covered by the papers increase to 82% from the period of 1998-2008 to 2009-2018 (Table 2). Most of the papers cover the subject area of “Agricultural and Biological Sciences” is simply because the term “agri-food” closely related to this subject area [7], [18]. While another subject area such; “Engineering” and “Computer Sciences” is covered by many papers viz. 18 and 15 papers consecutively, because these two areas are related to the basis of the technological development of traceability system [27],[28]. Business, Management and Accounting are another subject area with the most coverage since this area is dealing with the studies that implement traceability in business, business management, and accounting activities [29], [30].

The issue of food safety is undeniably crucial and inseparable from agri-food traceability. It is the main driving force of this field. When we added the word “food safety” in the query, we found 31 out of 67 or 46% of the papers included this phrase in their papers. We believe that this number could be bigger since this phrase can be written in other terms, for example, “food scares” or “food adulteration” [14],[31]. Therefore, the urgency of “food safety” issue is unquestionable. At the same time, the traceability of agri-food is the solution to this issue, to enable the tracing and tracking of every single entity such as the raw materials, the time and places of production, and other information related to food safety [27], [32]. The importance of agri-food traceability might be derived from the consumers‘ point of view, such as; it allows the chain of the product to be traced to ensure food security aspect [6], [7] it allows to evaluate food safety based on the information provided [33]. It can support an incentive scheme for effective and credible public policy of food safety regulatory system that might encourage food safety improvement [34]. From the producer side, traceability of agri-food will aid them in improving and maintaining the quality and safety of their products that lead to gaining consumers and public trust [27], which in turn will provide economic benefit.

5. Conclusion
The query of “agri-food traceability” revealed a relatively low number of published papers during 1998-2018. We compile 67 papers, most of which are written by the researcher from the developed countries. Most of the papers cover the subject area of “Agricultural and Biological Sciences,” while the number of covered areas grows as the number of papers does. This increase indicates that this research topic is expanding, as the traceability of agri-food research becomes compulsory to ensure food safety. We noticed that in the future, we need to cover multiple queries and deeper analysis to address various possibilities related to this topic.

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