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Analysis of Edible Film as Future Packaging using Bibliometric Method

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Abstract

The use of plastic as food packaging cannot be avoided in social life. Almost the entire food industry in the world uses plastic in its production process. However, the chemicals contained in plastics such as phthalates and BPA can have a negative impact, especially on the environment. One way to reduce plastic packaging is to using edible film instead of plastic packaging. The edible film is one of the advanced materials being developed in Indonesia and included in biodegradable. Thus, research on edible films is urgently needed as a food packaging innovation in the future, especially in the face of the Industrial Revolution Era 5.0. The aim of this research was to perform a bibliometric analysis of edible films using VOSviewer software. The data obtained is the result of a search based on the Scopus database with the keywords "Edible Film" and "Future Packaging" from 2018 to 2022. A total of 1,635 publications were published from around the world with an average of 327 publications per year. This shows that there is a high interest in edible film research from year to year. In Indonesia, the use of edible films as a substitute for plastic is still not optimal, so it is hoped that the use of edible films can have a major impact on the food industry to realize global development in the Industrial Revolution Era 5.0.

Keywords: Bibliometric Analysis, Edible Film, Future Packaging, Industrial Revolution 5.0

1. Introduction

Plastic is a synthetic polymer material that is cheap, easy to obtain, and very practical to use, so it is not surprising that most food packaging comes from plastic. Plastic products are ubiquitous in our daily lives and are causing serious environmental problems. Millions of tons of these nonbiodegradable polymers end up in the environment each year [1]. Global plastics production is expected to reach 390.7 million metric tons in 2021, representing a 4% annual increase [2]. As a result, the increase in the use of plastic will lead to the accumulation of plastic waste [3]. In Indonesia, there is a lot of plastic waste scattered around the environment. According to the National Waste Management Information System, every year Indonesia always contributes to a pile of waste of approximately 28.654 million tons/year, which consists of 17.3% plastic waste and 40.8% food waste. Food waste is usually garbage that comes from food packaging, which is mostly made of plastic.

The commodity of waste that is increasing, especially plastic waste can cause environmental pollution. Phthalates and Bisphenol-A (BPA) chemicals derived from plastic raw materials can cause health problems if they enter the human body through food or drinks exposed to plastic molecules. Various studies have linked BPA with several health effects, such as increasing prostate levels, decreasing testosterone levels, allowing cancer, and making a person hyperactive. Plastic waste can also produce pollutants because the chemicals in plastic contain toxins that are water-repellent and will stick to oil-based objects. The toxic chemicals in this plastic will accumulate with other plastic waste and will pollute the world's oceans [4].

Therefore, we need an appropriate solution to overcome the problem of plastic waste, which mostly comes from food packaging. With the development of the industrial world which is growing, we should take advantage of existing advanced materials related to packaging. The advanced edible film material was chosen to be one of the solutions to overcome the existing plastic waste problem. The edible film is a

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thin layer that can be consumed by humans because the raw material of the edible film comes from several natural ingredients, such as proteins, lipids, polysaccharides, or a combination of these materials [4]. Edible films also function to extend the shelf life of packaged products and as carriers of other compounds that are good for the human body. These compounds include vitamins, minerals, antioxidants, antimicrobials, preservatives, and ingredients to improve the taste.

On this occasion, edible films were analyzed using the bibliometric method in the last five years. The bibliometric method with the topic of the edible film is also assisted by the VOSviewer software with the Scopus database. George and Omoregbe state that the bibliometric method uses quantitative data analysis to identify publications and research trends in certain research areas [5,6]. This analysis uses the data to look at the author's collaborative network, scientific results and contributions, the impact of researchers' work, organizational collaborations and contributions, and country contributions to research. Bibliometric methods must go beyond simply communicating the results of performance analysis and scientific mapping generated by scientific databases (eg Scopus and Web of Science) and software (eg CiteSpace, Gephi, Leximancer, and VOSviewer). In particular, bibliometric methods are insufficient to describe only the main contributors (e.g., top authors, institutions, and countries) and topics (e.g., leading articles and keywords [7]. By using this method, the development of edible films can be analyzed for use as future food packaging.

2. Databases and Methods

The application of edible films has made progress in various worlds of the food industry. These hot topics can be analyzed using the VOSviewer software. Co-occurrence analysis is a bibliometric analysis method used to check the co-occurrence of keywords in published studies. The Scopus database is used to search by keywords (TITLE (edible AND film) OR KEY (edible AND film) OR TITLE (future AND packaging) OR KEY (future AND packaging)) AND PUBYEAR > 2017 AND PUBYEAR > 2017 and the year interval ranges from 2018 to 2022. A total of 1,635 publications were obtained from all over the world after filtering by relevance, The captured data was converted to RIS format and analyzed using the VOSviewer application. This application is used to visualize and analyze trends in the form of bibliometric maps. The article data is mapped from the database sources that have been prepared.

3. Results and Discussion

3.1. Publication trend

In this study, the scope of the journal is limited by the time of publication, namely in 2018 to 2022 to be exact on July 27, 2022, which is based on information taken from the Scopus database. A total of 1,635 journals on edible films have been published in the last five years. Figure 1 shows the number of edible film publications from year to year. In 2019 the number of publications is constant. Then in the following years, namely in 2020 and 2021, the number of publications increased drastically with the addition of 100 publications per year which can be underlined as evidence of the increasing interest of researchers in edible films. The average number of publications per year is 327 publications in the last five years. With this number of publications, it shows that there is a high interest in edible films which will certainly support future progress.

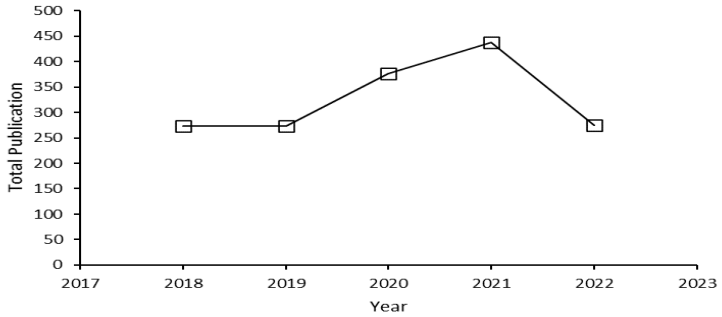

Figure 1: Total number of edible film publications by year (2018-2022)

3.2. Most influential source titles of edible film publications

To get an overview of the source titles that contribute to edible films, we identified top ten most influential sources of titles in the last five years (2018-2022). Table 1 shows that the International Journal of Biological Macromolecules has the highest rank with a total of 164 publications (28.3%). Then followed by Food Hydrocolloids and Iop Conference

Series Earth and Environmental Science, which has a total of 69 (11,9%) and 58 (10%) publications, respectively. Between the first and second source title, there is a significant percentage difference. This means the International Journal of Biological Macromolecules is the most influential source title with edible films over the past five years. Meanwhile, Food Chemistry and Food Packaging, and Shelf Life have fifth and sixth ranks. This means that the source of the title Food Chemistry and Food Packaging has a close relationship with edible film.

Table 1: Top 10 most influential source titles between 2018-2022

Position	Source Title	Total Publication
1	International Journal of Biological Macromolecules	164
2	Food Hydrocolloids	69
3	IOP Conference Series Earth and Environmental Science	58
4	LWT	53
5	Food Chemistry	50
6	Food Packaging and Shelf Life	49
7	Polymers	39
8	Carbohydrate Polymers	37
9	Foods	33
10	Coatings	28

3.3. Most productive country of edible film publications

Table 2 shows the top 10 countries that are active in publishing documents on the topic of edible film in Scopus data. China shows a total publication of 323 documents, this shows that China is active and has an interest in edible films. Then followed by Indonesia with a total publication of 160 documents. Several universities in Indonesia have been active in publishing edible film topics. Table 2 shows that several Indonesian universities such as Sebelas Maret University, Gadjah Mada University, Hassanudin University, and Diponegoro University have published their documents in large numbers. This shows that in Indonesia, the topic of edible films is slowly being studied, such as its characteristics when added glycerol and white turmeric filtrate, as well as carrageenan and citric acid [8,9]. After Indonesia, followed by India in third position which has published 148 documents. Iran is in fourth position with a total publication of 145 documents, followed by Brazil with 127 documents.

Table 2: Top 10 most productive country between 2018-2022

Position	Country	Total Publication
1	China	323
2	Indonesia	160
3	India	148
4	Iran	145
5	Brazil	127
6	United States	100
7	Turkey	80
8	Spain	73
9	Malaysia	54
10	Mexico	54

3.4. Most productive institutions of edible film publications

A total of 1,635 publications with the keyword “edible film” has been published in the last five years. This means that many institutions around the world have contributed to this journal each year. Here, we present the top 50 institutions in terms of total publications as seen in the Scopus database. The institution referred to here is the one affiliated with the author at the time of the edible film publication. During the five year period (2018-2022), Consejo Nacional de Investigaciones Científicas y Técnicas was the most productive institution with a total of 33 publications and was followed by the Ministry of Education China and Empresa Brasileira de Pesquisa Agropecuária - Embrapa with 27 and 25 publications, respectively (Table 3).

Table 3: Top 50 most productive institutions of edible film publications between 2018-2022

Position	Institution	Total Publication
1	Consejo Nacional de Investigaciones Científicas y Técnicas	33
2	Ministry of Education China	27
3	Empresa Brasileira de Pesquisa Agropecuária – Embrapa	25
4	Islamic Azad University	21
5	Universitas Sebelas Maret	19
6	Universidade Estadual Paulista Júlio de Mesquita Filho	18
7	Universidade de São Paulo	18
8	National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences	18
9	Shahid Beheshti University of Medical Sciences	18
10	Universiti Putra Malaysia	17
11	Sichuan Agricultural University	17
12	Cairo University	16
13	University of Tehran	16
14	Ferdowsi University of Mashhad	14
15	Jiangnan University	14
16	Universidade do Minho	14
17	Kasetsart University	14
18	Universidade Estadual de Campinas	14

Position	Institution	Total Publication
19	Kermanshah University of Medical Sciences	13
20	South China University of Technology	13
21	Universitas Gadjah Mada	13
22	Szkoła Główna Gospodarstwa Wiejskiego	13
23	International Iberian Nanotechnology Laboratory	13
24	University of Life Sciences in Lublin	12
25	Northwest A&F University	12
26	UCSI University	12
27	National Institute of Food Technology Entrepreneurship and Management	12
28	School of Nutrition Sciences and Food Technology, Kermanshah University of Medical Sciences	12
29	Urmia University	11
30	Universidad de Buenos Aires	11
31	China Agricultural University	11
32	Universidade Federal de São Carlos	11
33	Università degli Studi di Napoli Federico II	11
34	Jiangsu University	11
35	Universidade Federal do Ceará	11
36	Northeast Agricultural University	11
37	Tabriz University of Medical Sciences	11
38	Hasanuddin University	11
39	Lembaga Ilmu Pengetahuan Indonesia	11
40	Ministry of Agriculture of the People's Republic of China	11
41	Universidade do Porto	10
42	Cornell University	10
43	Universidade Federal do Parana	10
44	Instituto Politécnico Nacional	10
45	Universitas Diponegoro	10
46	Embrapa Agroindústria Tropical	10
47	Zhejiang University	9
48	Nanjing University of Finance and EcoNomics	9
49	Universidade Federal de Lavras	9
50	Cairo University Faculty of Science	9

3.5. Analysis of the terms' occurrences

We have examined the appearance of phrases taken from the paper title field using the VOSviewer program to present a summary that has been reflected in the journal throughout five years (2018–2022). The keyword lists supplied in the papers have been utilized by certain authors to highlight research patterns in particular publications [10–15]. The network of terms' occurrences is depicted in Figure 2. The size of the circle or node of a term is proportional to the number of occurrences of the term in the article. From these results obtained 517 items with 5 clusters, 54.126 links, and a total link strength of 18.8943. Words such as edible film, tensile strength, food packaging, chemistry, and chitosan are the most widely used terms, this is a result of the interest in developing packaging technology and functional solutions. Edible films have made significant contributions to the field of food science, as seen above for the most referenced works in journals, particularly in the area of creating food packaging.

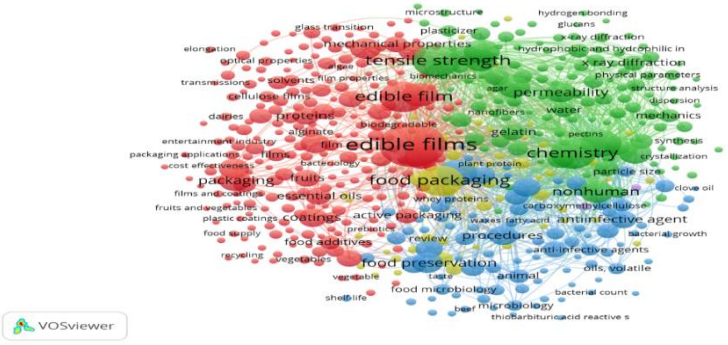

Figure 2: Co-occurrence Network

Cluster 1. The item with the largest red circle in cluster 1 is edible films with a total link strength of 10,502. When viewed from the branching, edible films branched with antioxidants which means there is a close relationship between both of them. According to Estiningtyas, in their study of edible

films containing ginger extract, they found that the addition of antioxidant concentration in edible films had a significant effect on the level of rancidity in fatty foods such as sausages [16]. Antioxidant edible films provide very beneficial properties for coated food stuffs because antioxidant compounds improve the quality and safety of foodstuffs from enzymatic browning and protect from oxygen or fat oxidation which can extend the shelf life of food stuffs [10]. In addition, edible films also branch out with the packaging. Several applications of edible films have been explored to date for use as edible coatings/packaging on various types of food such as fruits, vegetables, meat, and seafood. Then, edible films are also branched with proteins, polysaccharides, lipids, composite films, and nanoparticles. Where these materials come from natural polymers used in edible packaging [11].

Cluster 2. The item with the largest green circle in cluster 2 is chemistry with a total link strength of 8,476. This shows that edible films are closely related to chemistry. When viewed from the closest branching, chemistry branched off with the article. Where there are also many chemical articles that contain edible films on various platforms. For example, there are 1,635 publications around the world regarding edible films based on the Scopus database and not including other databases. In addition, the chemistry is also branched by tensile strength. Where the tensile strength is one of the mechanical properties of edible films in the field of chemistry which can be interpreted as the maximum strength received by the film before breaking. Factors that can affect the tensile strength properties are the amount of concentration added and the type of edible film-forming material used. Based on research conducted by Polnaya, the addition of 0.5% glycerol concentration showed a higher average tensile strength value than 1% and 1.5% glycerol concentrations [17]. This shows that the higher glycerol concentration can cause a decrease in the tensile strength of the edible film. Glycerol can reduce the interaction between molecules and weaken the tensile strength of the resulting edible film so that an elastic film will be obtained. In another study by Salama, the addition of microcrystalline cellulose (MCC) to the manufacture of edible films from starch also caused an increase in tensile strength. This is due to the better interfacial interaction or/and degree of cross-linking between the MCC as a result of the chemical similarity (polysaccharide structure) of the constituents [18] .

Cluster 3. The item with the largest blue circle in cluster 3 is chitosan with a total link strength of 4,255. This shows that the edible film is related to chitosan. Chitosan is appealing due to its non-toxicity, biodegradability, and biocompatibility [19]. In a study conducted by Adetunji, hardness is one of the factors that influence the shelf life of citrus fruits [12]. Based on the treatment, chitosan and rhamnolipid coating could prevent the loss of hardness after 5 weeks of storage followed by fruit softening at the end of 8 weeks. It was also found that the combination treatment of chitosan and rhamnolipid was more effective in maintaining the elasticity of the lime compared to other treatments. This is due to the antifungal activity of chitosan which can reduce infection in fruits so that the shelf life of fruit is longer. In addition, chitosan can also minimize acidity in fruit during storage.

Cluster 4. The item with the largest yellow circle in cluster 4 is food packaging with a total link strength of 6,843. Food packaging has branches with several items. One of them is nanocomposite. Research on edible films with TiO_2 nanocomposite film in food packaging shows that the addition of TiO_2 nanoparticles can improve the physical properties of whey protein concentrate-based edible films. The nanoemulsion-based films also display better encapsulation properties, featuring lower oil release and increased transparency. Smaller droplets allow the manufacture of films containing fewer pores than films with micro-droplets and thus can produce better mechanical properties. Nano-based films have physical properties suitable for food packaging [14]. Meanwhile, food packaging also has branches with humans. A review of microplastics from food packaging by Du estimates that human consumption of take-out food is about 2,977 microplastics per person per year and people who consume plastic packaged foods 4-7 times a week may be exposed to ingesting about 12-203 microplastics per week released through the container [20]. Microplastics can have a bad impact on humans. The entry of microplastics into human cells can result in acute inflammation and cell damage or cell death. In addition, it can also affect the production of cytokines from immune cells [15]. From this, it can be concluded that food packaging materials play an important role in human life.

Cluster 5. The item with the purple circle in cluster 5 is Carboxymethylcellulose which is branched with Carboxymethylcellulose Sodium. The research on the effect of murta extract on gas and water vapor permeability of edible film based on carboxymethylcellulose showed that the water vapor permeability of edible film based on carboxymethylcellulose with marta leaf extract was smaller than that of other edible films. Edible films containing flavonols can significantly reduce water vapor permeability due to fewer -OH groups. This study shows that the addition of murta leaves into edible film based on carboxymethylcellulose can modify the permeability of water vapor, oxygen, and carbon dioxide [21].

4. Conclusion

A bibliometric review of edible films in the last five years shows a significant growth of the journal during the 2019-2021 period. International Journal of Biological Macromolecules is the most source title of the top 10 source titles. China is the most productive country in publishing journals, followed by Iran and Brazil. Meanwhile, Consejo Nacional de Investigaciones Científicas y Técnicas is the most productive institution among 50 institutions with a total of 33 publications. The Visualization of Similarities (VOSviewer) reveals strong collaboration between one network and another. This shows that research during 2018-2022 such as edible films, tensile strength, food packaging, chemistry, and chitosan are still interesting for journals.

5. Future Direction

The importance of food packaging as a topic for publication of edible films may be due to the evidence that packaging made of plastic can cause health problems if it enters the human body through food or drinks exposed to plastic molecules. Edible films should stimulate the investigation/publication of innovative and interdisciplinary studies aimed at clarifying how mixtures of food components interact to promote health and are more environmentally friendly. The edible film is a thin layer that may be digested by people. Because the raw material of edible film is made of a variety of natural substances, including proteins, lipids, polysaccharides, or a combination of these elements, they should be useful in promoting good health. Similarly, Indonesia's preparation for the era of Revolution 5.0. Considering the concept of revolution 5.0 is to equalize welfare at all levels of society. So edible film must be one of the advanced materials that can be used as future packaging that is environmentally friendly and helps the preparation process for the 5.0 revolution.

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