

Comparative Study in Functional Food Technology: A Bibliometric Analysis

Ria Hardiyati¹, Indah Purwaningsih¹, Muhammad Zulhamdani¹, Chichi Sintia Laksani¹ and Yan Rianto¹

¹Indonesian Institute of Sciences, Gatot Subroto Street No. 10, South Jakarta, Jakarta, Indonesia

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Abstract: Growth in the global food and beverage industry continues driven by health and wellness. So society has high expectations for companies in this industry that products can meet the demand of consumers for a healthy lifestyle. From that situation, functional food has a specific role. Data from Grand View Research Report shows that the global Functional Foods market is valued at 153,600 million US\$ in 2018 and is expected to reach 260,400 million US\$ by the end of 2025. The functional food and nutraceutical market in the USA currently the most massive and most rapidly expanding in the world with supports major imports from Japan, North and South Korea, China, India, Brazil, the European Union, Australia, New Zealand and other parts of the world. If Indonesia wants to take part in the functional food market, it is necessary to advance research and development (R&D) in functional food. So it is necessary to study the development of functional food R&D from several leading countries. This study sought to examine the development of functional food R&D in Brazil, India, China, and Germany, based on scientific publications in Scopus. The analysis was carried out using a bibliometric approach and co-word analysis. The results of this study provide an overview of the development of functional food R&D, especially technologies in Indonesia and 4 other countries.

1 INTRODUCTION

Growth in the global food and beverage industry continues driven by health and wellness. So society has high expectations for companies in this industry that products can meet the demand of consumers for a healthy lifestyle. From that situation, functional food has a specific role. Data from Grand View Research Report shows that the global Functional Foods market is valued at 153,600 million US\$ in 2018 and is expected to reach 260,400 million US\$ by the end of 2025. The functional food and nutraceutical market in the USA currently the most massive and most rapidly expanding in the world with supports major imports from Japan, North and South Korea, China, India, Brazil, the European Union, Australia, New Zealand and other parts of the world (Vergari, Tibuzzi and Basile, 2010). The process development of new functional food is expensive. The requirement to develop a functional

food product is detailed knowledge of the products and the customers. The food industry takes into consideration many variables to develop or re-engineer functional products in order to meet needs and expectancies in the area of functional foods (Betoret *et al.*, 2011). Food companies are developing technologies for processing health and wellness products that will improve the efficacy of these products, maximize the potential benefits to consumers, and be cost-effective for the industry's survival in a competitive marketplace (Aryee and Boye, 2015). That is why we need to know the development of functional food research, especially regarding developing technologies and compare with countries whose functional food industries have developed.

Bibliometric analysis is commonly applied to track the developing research trends, or finding out the influences of publications, also to compare the academic performance among regions in a certain research field. This bibliometric technique has been applied in the domain of obesity using data from PubMed (Vioque *et al.*, 2010), and another study

analyzed research trends from 1993 to 2012 with Scopus as the data source (Khan *et al.*, 2016). Quantitative approaches, such as computer-based methods and bibliometrics, can provide a complementary result to handle massive data for exploring promising technologies (Ciarli, Coad and Rafols, 2015). In particular, bibliometrics has been widely used as a powerful and helpful tool for monitoring research trends (Soranzo, Nosella and Filippini, 2016) or technological trajectories (Roepke and Moehle, 2014; Chen *et al.*, 2015; Zhou *et al.*, 2015; Marvin *et al.*, 2017; Park and Magee, 2017) or analyzing technological changes (Cho and Kim, 2014; Lee, Lee and Sohn, 2016) using various data, such as publications, patents, and other. However, the assessment of research output for food science and technology, in general, and for functional food, in particular, are scarce in the literature.

This study aimed to examine the development of functional food research, especially regarding developing technologies in Indonesia and compare it with Brazil, India, China, and Germany, based on scientific publications in Scopus. We investigated the research trends through a bibliometric analysis.

2 MATERIALS AND METHODS

2.1 Search strategy

Bibliometric data can be acquired through various search engines, one of them is the Scopus. This database was selected to collect for as much as possible published articles on functional food. The justification we use Scopus as our data source to retrieve bibliometric data given is because it has broader resources and is consistently more accurate than other alternatives such as PubMed, Web of Science and Google Scholar (Falagas *et al.*, 2008; Kulkarni *et al.*, 2009; Khan *et al.*, 2016).

Researchers in several domains have applied the bibliometric analysis. Recently, the research scope expands constantly, and people use it for reference management or literature study. Co-word analysis, proposed in the late 70s in the 20th century by the French bibliometric scientists. The summarize of its principle is when two or more keywords representing a special research topic appeared in the same dissertation have essential relationships (Chen *et al.*, 2016). The more co-occurrence between two keywords, it means the closer their relationship is. This method is helpful for researchers to learn an overview of a field. So it plays an essential role in

identifying the value of academic discipline (Musgrove *et al.*, 2003; Zong *et al.*, 2013).

The Scopus database was searched from its inception until July 25, 2019 with limitation in affiliation country. The keywords pertaining to functional food were: functional beverage, functional food, and functional drink. The keywords regarding function of bioactive compound in food were: anti diabetic, antioxidant activity, prebiotic, anti-aging, anti-cholesterol, anti-cancer, oxidative stress, antihypertensive, cardiovascular drug, antibacterial activity, anti diarrhea, immunology, probiotic, anti-obesity, noncommunicable disease, anti-allergic. The two sets of keywords were searched and combining with the "AND" logic in the "Article title/Abstract/Keywords" fields. The final search query was built like this:

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((TITLE-ABS-KEY("functional beverage") OR TITLE-ABS-KEY("functional food") OR TITLE-ABS-KEY("functional drink")) AND AFFILCOUNTRY(Indonesia)) OR ( TITLE-ABS-KEY ("food" ) OR TITLE-ABS-KEY ( "bioactive compound" ) AND ( TITLE-ABS-KEY ( "anti diabetic" ) OR TITLE-ABS-KEY ( "Antioxidant Activity" ) OR TITLE-ABS-KEY ( prebiotic ) OR TITLE-ABS-KEY ( "anti aging" ) OR TITLE-ABS-KEY ( "anti cholesterol" ) OR TITLE-ABS-KEY ( "anti cancer" ) OR TITLE-ABS-KEY ( "Oxidative Stress" ) OR TITLE-ABS-KEY ( "antihypertensive" ) OR TITLE-ABS-KEY ( "cardiovascular drug" ) OR TITLE-ABS-KEY ( "Antibacterial Activity" ) OR TITLE-ABS-KEY ( "anti diarrhea" ) OR TITLE-ABS-KEY ( "immunology" ) OR TITLE-ABS-KEY ( probiotic ) OR TITLE-ABS-KEY ( "anti obesity" ) OR TITLE-ABS-KEY ( "non communicable disease" ) OR TITLE-ABS-KEY ( "anti allergic" ) ) ) AND AFFILCOUNTRY ( indonesia ) ).
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All of the bibliographical information, citation information, abstract and keywords, funding details and other information of the retrieved publications were exported with CSV format, for further data processing.

2.2 Data analysis

All bibliometric information exported into CSV format from the Scopus database. Data visualization and analysis were conducted using the VOSviewer technique to create co-word networks based on title (van Eck and Waltman, 2010).

Co-Word Network Analysis was carried out to examine the co-word network in functional foods research. Co-Word Analysis also called co-

occurrence map in Library and Information Science. It is one of the quantitative methods for analyzing scientific publications. In general, this method is used to understand current conditions of the research theme in certain fields, and sometimes it used to examine the evolution of the theme that has occurred. Co-Word Analysis is performed by looking at the occurrence of a term in a set of documents, then linking the terms that appear on the same document. The form of document can be a book, journal, abstract, or title. Data mapping and term of technologies in functional food extracted from VOSviewer.

3 RESULTS

3.1 Number of publications

Research on functional foods in Indonesia yielded a total of 568 publications. The first article on functional foods published in 1990, and the annual publication numbers were increased in the following nearly 10 years till 2019. A dramatic growth observed in the last 5 years from 2015 to 2019. The highest number of annual publications was seen in 2018, totaling 171 publications. In terms of document type, the majority were research articles ($n=368$, 64.79%), followed by conference paper ($n=157$, 27.64%) and review articles ($n=27$, 4.75%).

The number of Indonesian publications in functional food is still far behind when compared to 4 other countries, namely Brazil, China, India, and Germany (see Figure 1). Even with India and Brazil which have many similarities, both from the potential of raw materials from nature and the progress of their research, with Indonesia.

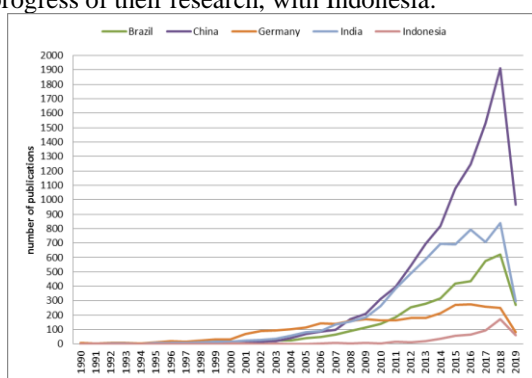


Figure 1: Indonesia's annual publication of functional food compared to other countries for last 10 years.

In 2011, number of Indonesian publication in functional food increase sharply, Brazil in 2004,

China in 2005, India in 2006, and Germany in 2007. Also in 2011, Regulation of the head of The National Agency of Drug & Food Control (BPOM) regarding health claims in labels and processed food advertising supervision is enacted. In this regulation, claim must have scientific proof. This significant augmentation of publication number on functional foods has relation with needs of scientific proof for health claim.

This condition also similar in Brazil, China, India, and Germany. Brazil sharply increase in 2004, where in the same year regulation about the scientific proof of health claims was enacted. In 2004, ANVISA published Guidelines for the use, in labels of food, of claims for nutrients with functions widely recognized by the scientific community. China in 2005 enacted The Administration Regulation for Health Food, India in 2005 enacted The Food Safety and Standards Act, and in 2007 Germany/EU enacted The Administration Regulation for Health Food.

3.2 Co-Word Analysis

Figure 2(a) and 2(b) shows visualization of co-word analysis based on document title of Indonesian publication in functional foods. We can see that prior to 2011, functional food research was still partial and not yet focused on providing scientific evidence of health claims. Starting in 2011, functional food research has focused on providing scientific evidence on health claims. This can be seen from the terms that appear like "effect", "characterization", "identification", and "bioactive compound".

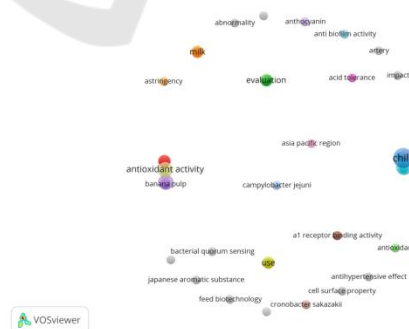


Figure 2(a): Network visualization of Indonesian publication in 1990 – 2010.

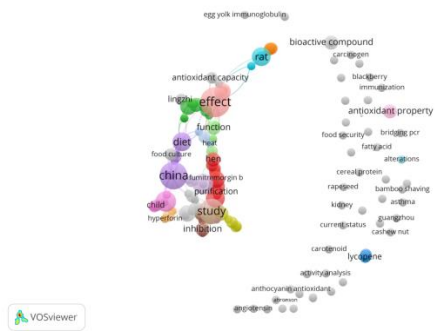


Figure 5(a): Network visualization of Chinese publication in 1980 – 2004.

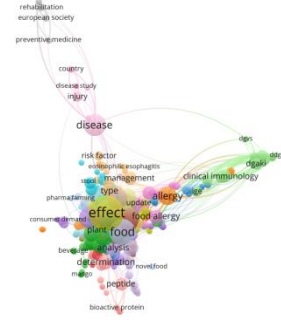


Figure 6(b): Network visualization of Germany publication in 2007 – 2019.

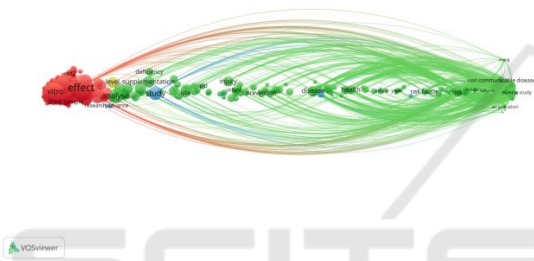


Figure 5(b): Network visualization of Chinese publication in 2005 – 2019.

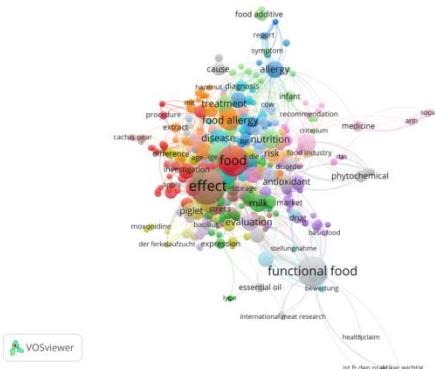


Figure 6(a): Network visualization of Germany publication in 1974 – 2006.

There is the fact that thousands of FDA regulations impact the willingness of manufacturers to branch outside their “safety-net” and develop new ideas, technologies and products. The FDA outline and propose the regulations through influence the ingredients, technological processes, packaging, and labeling involved in the development (Alicea A. Glueck-Chaloupka, Capella and Coggins, 2005).

4 DISCUSSION

Indonesian technology capacity on functional food development similar compare to Brazil, India, China, and Germany. Technology capacity before health claim regulation is enacted between Indonesia, Brazil, India, China, and Germany there is no too much significant difference (see Table 1).

As well as after health claim regulation is enacted. Indonesian researchers possess functional food technology that is not much different from researchers from Brazil, India, China, and Germany (see Table 2). But why Indonesia's functional food industry lags behind Brazil, India, China, and Germany?

Table 1: Functional food technologies before health claim regulation is enacted.

Indonesia (1990-2010)	Brazil (1979-2003)	India (1971-2005)	Germany (1968-2006)	China (1980-2005)
extraction	extraction	fermentation	extraction	low feed efficient broiler
feed biotechnology		characterization	enrichment	vacuum impregnation method
vapor contact method			probiotic feed additive	
roasting			characterization	

Indonesia (1990-2010)	Brazil (1979-2003)	India (1971-2005)	Germany (1968-2006)	China (1980-2005)
edible film (bactery, biofilm)			identification	
identification				
possible compound				

Table 2: Functional food technologies after enact health claim regulation.

Indonesia (2011-2019)	Brazil (2004-2019)	India (2006-2019)	Germany (2007-2019)	China (2006-2019)
soxhlet extraction	extraction, ultrasound assisted extraction	extraction solvent, ultrasound assisted extraction	solvent extract, extraction	extraction solvent, ultrasound assisted extraction
fortification, enriched	fortification, enriched	fortification		enrichment
crossbreed	cultivation	feed additive		feed additive
roasting	roasting			
freezing				
gamma irradiation		gamma irradiation, irradiation		irradiation
encapsulation, microencapsulation, microparticles and nanoparticles	encapsulation, microencapsulation	encapsulation, microencapsulation	microencapsulation	encapsulation, microencapsulation
high pressure	high pressure	high pressure	high pressure	high pressure
extrusion	extrusion	extrusion		
hydrolysis enzymatic	enzymatic treatment, enzymatic hydrolysis	enzymatic hydrolysis		enzymatic treatment
fermentation	fermentation	fermentation	food fermentation	fermentation
		metabolic engineering		
edible films and coatings	film and coating	edible coating		edible coating
	vacuum impregnation			

The trajectories of technological possibilities are entirely foreseeable with an increased gain of knowledge, insight and engineering capacities. However, legal, economic, and societal aspects, as well as public opinion, play a significant role in determining whether new technologies and methods may be applied or not.

5 CONCLUSIONS

Indonesian technology development before health claim regulation is enacted similarly compared to Brazil, China, India, and German. As well as after health claim regulation is enacted. However, why Indonesia's functional food industry lags behind Brazil, India, China, and Germany? The trajectories of technological possibilities are entirely foreseeable with an increased gain of knowledge, insight and engineering capacities. However, legal, economic, and societal aspects, as well as public opinion, play a significant role in determining whether new technologies and methods may be applied or not..

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