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Mapping of palm oil technology based on patent information analysis

M H Wibowo^{1,2}, A M Fauzi³, F M Taqi⁴

¹ Business School, Bogor Agricultural University, Jalan Pajajaran Bogor 16151, Indonesia e-mail: hendra@apps.ipb.ac.id

² Directorate of Innovation and Entrepreneurship, Bogor Agricultural University. Gedung AH Nasoetion Lantai 5, Kampus IPB Dramaga Bogor 16680, Indonesia

³ Department of Agroindustrial Technology, Bogor Agricultural University, Gedung Fakultas Teknologi Pertanian Lantai 2, Kampus IPB Dramaga Bogor 16680, Indonesia

⁴ Department of Food Science and Technology, Bogor Agricultural University, Gedung Fakultas Teknologi Pertanian Lantai 2, Kampus IPB Dramaga Bogor 16680, Indonesia

Abstract. Patent system has been implemented globally to protect intellectual property in technology. Patent information analysis has been used for various purposes, including technology mapping, technology forecasts, business intelligence, patent portfolios, and others. Indonesia is the largest producer and exporter of palm oil in the world thus palm oil is one of Indonesia's largest foreign exchange earning commodities, but Indonesia's palm oil research activities are still lagging behind Malaysia. This study aims to map the conditions and development of palm oil technology in the world and Indonesia based on patent information analysis that expected to be an input for researchers & policy maker (government, university, R&D institution) in structuring of research and development strategic planning to produce applicative researches which suitable to industry needs. Patent information analysis of palm oil in this study includes technology life cycle, technology classification, patent applicants, market size of technology, and experts of palm oil technology. Mapping of palm oil technology based on patent information analysis in this study shows the development of palm oil technology both in the world and Indonesia are in the stage of growth. In the period 1997-2016, technologies that were widely developed were production of oil and fat from palm oil raw materials and enzyme utilization for synthesis of organic compounds, processing of wastewater and fertilizers from palm oil waste, cultivation or nursery of oil palm, herbal preparations, and utilization of oil palm biomass for particle board. Data on patent applicants for palm oil in the world shows that 83% of patent applicants came from companies, where the Malaysian Palm Oil Board (MPOB) is the largest producer of palm oil technology in the world.

Keywords: patent analysis, patent information, technology mapping, palm oil

1. Introduction

Palm oil industry is an important part in the Indonesian economy which currently places Indonesia as the largest palm oil's producer and exporter in the world. Palm oil industry had become one of the 22 main economic activities included in the Masterplan of Acceleration and Expansion of Indonesian Economic Development (Masterplan Percepatan dan Perluasan Pembangunan Ekonomi Indonesia/MP3EI) 2011-2025 [1]. Palm Oil Analytics [2] showed that Indonesia's palm oil production was 34.520.000 tons, almost double the production of Malaysian palm oil (Table 1). Indonesia contributed



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48% and Malaysia 37% of the total volume of world palm oil production, meaning that 85% of the world market for palm oil controlled by Indonesia and Malaysia [3]. Palm oil is also one of Indonesia's export commodities and Indonesia's largest foreign exchange earner in addition to tourism, crude oil and gas. The export value of Indonesian palm oil in 2016 was USD 16,277,282,000 [4].

Research and development which directly influenced the development of national palm oil industry is still very much required. The Palm Oil Plantation Fund Management Board (Badan Pengelola Dana Perkebunan Kelapa Sawit / BPD PKS) [3] stated that research activity is the foundation of downstream industry required as the spearhead of industrial development, which Indonesia still possess a big task to pursue its backwardness over Malaysia – who have been the benchmark in terms of palm oil industry development and Crude Palm Oil (CPO) downstream technology.

Tabel 1. The Top Ten Palm Oil Producing Countries in 2016 [2].

No	Country	Production (000 ton)
1.	Indonesia	34,520
2.	Malaysia	17,320
3.	Thailand	2,300
4.	Colombia	1,280
5.	Nigeria	970
6.	Ecuador	560
7.	Honduras	545
8.	Papua New Guinea	522
9.	Ghana	520
10.	Guatemala	515

The condition of palm oil technology is an essential matter to be comprehended as an effort of policy making, research and development implementation as well as building a cooperation between research and business. The information included in the patent document can be utilized to comprehend the condition of palm oil technology development also as a tool for business intelligence as well as development strategic planning and investment in the research. Statistically, patent had been used as an indicator of technology activity, together with other data used in the innovation field decision making analysis, such as the role of intellectual property in economic performance, entrepreneurship, as well as science and technology system [5]. Patent analysis information report designed to efficiently solves problems in the decision making of various field of technology based on the data and information [6].

The patent system has been implemented globally to protect intellectual creations in the field of technology; and the technology generally used by the industry was the patent based technology. Patent documents contained technical information of a certain field of technology which is applicative. An invention under current condition is not a truly new technology in the world, the fact shows that most of the new idea developed from existing ideas. The patents found across the United States of America 80% to 90% of them were estimated as a development of existing patents [7].

Many benefits can be obtained from patent documents information, among others: to avoid research and development duplication; to reveal the experts and institution/company in the world who produce the most number of technology in a certain field; to find out technology development trend of a certain field; to discover innovative activities and business development direction conducted by the competitor (business intelligence); and assist business planning and decision making such as technology partnership, merger and acquisition [8,9]. This study aims to map the condition and development of palm oil technology in the world and Indonesia based on patent information analysis. The result of palm oil technology mapping in this study is expected to be an input for researchers and policy maker (university, R&D institution, government) in structuring of research and development strategic planning to produce applicative researches which suitable to industry needs.

2. Patent Information Analysis

Patent is one type of legal protection for intellectual property (IP) in the field of technology, either in the form of process or method, formula or composition, product, instruments or machines. Patent is an exclusive right granted by the State to the inventors as the result of their invention in technology field for a certain period of time to perform the invention mentioned themselves or giving approval to other party to implement it [10].

Patent document utilization can be categorized into three, namely: 1) patent document as scientific source of information; 2) information utilization of patent document in research and development activities; and 3) patent document for business benefit [9]. Up to date and complete information regarding one technology field contained in the patent document can be used as one of the references. Eusebi and Silbergliitt [11] revealed that many researchers have analyzed bibliography data related with technical and patent papers to obtained information regarding the latest technology. Patent data is a valuable source of information which enable decision maker to: (1) assess their own technology portfolios compared to the competition; (2) assess the attractiveness of technology, especially new technology that has the potential to be a threat or vice versa to be an opportunity for business; (3) recognize company's strategic alteration in a competitive environment; (4) identify and evaluate external resources for cooperation purposes (i.e Management and Accounting, research and development cooperation, etc); (5) assessing patent status in business fields that can be explored; (6) evaluate important market partner, especially customer and vendor, to determine whether companys' research and development strategy in line with customers' needs; and (7) to upgrade human resources management related inventor or leading experts in a certain field of technology (specific) [8].

WIPO [12] devided patent information main users group as follow: industry; research and development (R&D) institutions; government authorities; small and medium enterprises (SMEs); inventor/individual; professionals in patent field, for example patent agency, researchers, data bank producer; educational institutions and university students. There are many designation used to analysed patent information, namely patent map analysis, patent portfolio analysis, etc. Fabry et al [13] used patent portfolio analysis as a tool utilized to identify research and development and business opportunity. According to Trippe [6], based on his report, patent information analysis can be mentioned with several terminology, namely patent landscape, patent map, watch or alerts, freedom-to-operate / clearance, patentability / prior art, validity, general statistics.

Several studies related to patent information analysis have been conducted for various field of technology and the methods used can be view in table 2. The aspects studied in patent information analysis described in table 3.

Table 2. Patent information analysis for various field of technology and the method used.

No	Author	Method	Study Result
1.	Suprijadi [14]	Zipf Curve and Bibliometric Analysis	Determining renewable energy technology sectors based on patent information. According to patent data analysis collected from international data, identified as many as 202 technology sectors and three technology sector groups namely group categorized as trivial, interesting and noise group.
2.	Jun and Lee [15]	Text mining technique, statistical inference and neural networks method	The model that can be implemented in forecasting the development of various technology field (emerging technology forecasting/ETF). An example of the technology being studied is the nanotechnology.
3.	Poranki [16]	<i>Delphi, Analogy Methods, Extrapolation, Statistics, dan Causal Relations</i>	Examine the potential of new technology growth based on patent analysis for flexible electronic technology case. Several innovation based new technology considered not mature enough to show a high growth, despite potential. This study will not

No	Author	Method	Study Result
4.	Kim [17]	Quantitative data analysis, ANOVA or t-test technique	only help in technology evaluation, but also provide a better understanding of emerging technologies, especially flexible electronic applications. The road map generated providing valuable information for non woven tissue industry regarding potential market, condition when tissue watered, including challenge, strengthness, opportunity and solution. Study result providing a very valuable information for research invesment, development and manufacture facility.
5.	Sandal and Kumar [18]	Text mining and quantitative analysis, namely patent maps and patent network analysis	The tracer study and patent document analysis to solve R&D problems in the field of medicine. The patent analysis combination narrow the patent search result to 14 of the most relevant patent documents (drug delivery, inhalation and fentanyl).
6.	Kim et al [19]	Text-mining, term frequency - inverse document frequency (TF-IDF), topic model, cross-impact analysis, association rule mining, key word anayisis, social network analysis, and applicant analysis	Developing a hybrid model patent analysis for sustainable technology management requirement in humanoid robot industry. Cross-impact combination analysis result described in Weighted network graph for main cross-impact matrix and bipartite network graph for technology company matrix. The model developed is useful to extend sustainable technology management strategy, because it's possible to comprehend the technology specifically.
7.	Garland [20]	Text mining and TRIZ TF	The application of both method combination, text mining and TRIZ TF will increase technology forecasting process period (longer time). Text mining and TRIZ TF method provides different type of information. Text mining method is an exact method to identify the trend and technology tracking from time to time, and to identify technology development stage but limited in predicting the developing technology for the future. TRIZ TF method is an exact method to determine technology system maturity, understanding the technology component which contributes to and identifies future possibility but limited in forecasting a more specific technology.
8.	Fujii et al [21]	Logarithmic Mean Divisia Index (LMDI)	Studying research and development strategy for biology technology (biochemistry and biotechnology; medicine and disease; food material and agriculture) based on patent data analysis from Japanese manufacture company.

Tabel 3. The aspects studied in patent information analysis.

No	Author, year and research title	Method	Examined Aspects
1.	Egan [22]	Descriptive Statistic	Patent quotation (sitiation), commercialization strategy, triumph possibility and the value of succes.
2.	Fabry et al [13]	Patent portfolio analysis	Patent activity, patent strength and patent quality presented in the form of graph and spider diagram.

No	Author, year and research title	Method	Examined Aspects
3.	Shuang and Yan [23]	Patent analysis	Technology development trend, area distribution, patent applicant, technology classification and technology distribution.
4.	She et al [24]	Patent information analysis	Applicant rank (top ten patent applicant), patent classification (top 10) in accordance to International Patent Classification (IPC), patent type or variety (invention patent and new practical patent), patent legal status (valid or invalid).
5.	Altuntas et al [25]	S Curve technology life cycle (TLC)	Technology life cycle, technology diffusion velocity, patent strength and patent expansion.

3. Methodology and Limitations

3.1. Research design and methodology

Research design used is secondary data content analysis from written document, which is bibliography patent document data. The method used in this research presented in Figure 1. Patent data obtained from data base that accessed by online and categorized into two groups, namely 1) world patent data and 2) Indonesia patent data. World patent data harvested with the tool of Patent Inspiration software basic licence version which contained EPO database consisting two data base, namely: 1) EPO (European Patent Office) and 2) patent inspiration data base. EPO data base contained patent bibliography data (title, abstract, applicant, inventor, quotes/sitation, classification code) of more than 102 countries which is updated every week. Patent inspiration data base contains complete text (claim and description) from the main search authorities (WO, EP, US, CA, etc).

World patent data harvesting in Patent Inspiration software conducted based on the keywords “palm oil” or “oil palm” or “palm kernel” with search filter as follow:

- *field: title*
- *show only one per family: order by text content*
- *patents without empty title or abstract*

Searching with the above key words in the field title conducted to obtained more focused search result and the certainty that patent documents obtained are palm oil technology. Total palm oil patent application in the world generated from Patent Inspiration database since 1904 to September 28, 2017 were 695 patent documents.

Indonesia patent data obtained from the data base found in Directorate General of Intellectual Property (DGIP) Ministry of Law and Human Rights of Republic Indonesia (Kemenkumham RI), namely patent data which can be accessed from <http://e-statuski.dgip.go.id/>. Based on the search in May 16, 2017 with the keyword “sawit”, the total palm oil patent application listed in Indonesia since 1989 to 2016 were 331 patent documents.

Bibliography data which contained in patent document resulted from patent data harvesting, next would be analyzed quantitatively. The quantitative analysis of world patent information using the available tool in form of patent information analysis software namely Patent Inspiration Basic License version from AULIVE (<http://www.patentinspiration.com/>) and Microsoft Excell program. Indonesia patent information quantitative data analyzed using Microsoft Excell program. The analyzed aspects based on the information within patent documents in this research are as follow:

1. Technology Life Cycle (TLC) of palm oil, conducted by building S curve based on cumulative amount of palm oil patent registration per year from 1997 to 2016. TLC analysis used to explore the changes and development of palm oil technology.
2. Classification of palm oil technology, conducted by classifying palm oil technology categories based on number of International Patent Classification (IPC) code distribution. IPC analysis used to reveal most produced fields of technology. In this research, the big top ten classification of palm oil technology would be collected based on IPC main group.

3. Patent producer (technology) of palm oil, have analyzed major palm oil producer countries, the big 10 palm oil patent applicants and research collaboration between company and higher education institution. The primary palm oil patent producer countries determined based on the distribution of patents number per applicant country. Primary patent applicant conducted by counting the number of patents produced by every applicant and identifying the top 10 patent applicants as well as the percentage of share from total palm oil patents. Besides that, the sharing of patent applicants can be viewed based on company group, academic and company-academic joint venture by calculating the number of patent registered by applicant company, academic (higher education institution) and company-academic joint venture. Collaboration or cooperation intertwined between company and higher education institution viewed based on joint patent application.
4. Market size technology, conducted to reveal the destined area of application or implementation of a technology and identifying the market size of a patent. Generally the countries which become the destination of patent registration analyzed based on prefix country, while the market size of a certain patent can be identified based on the number of patent family. In this study, the top 10 patent have been identified to have the biggest patent family in the field of palm oil technology and its market area countries.

At the final stage, a matrix of palm oil technology mapping was build which obtained from the quantative analysis result of bibliography data in accordance with the aspects studied. Matrix structuring will make the palm oil technology development easier to be review based on patent information analysis.

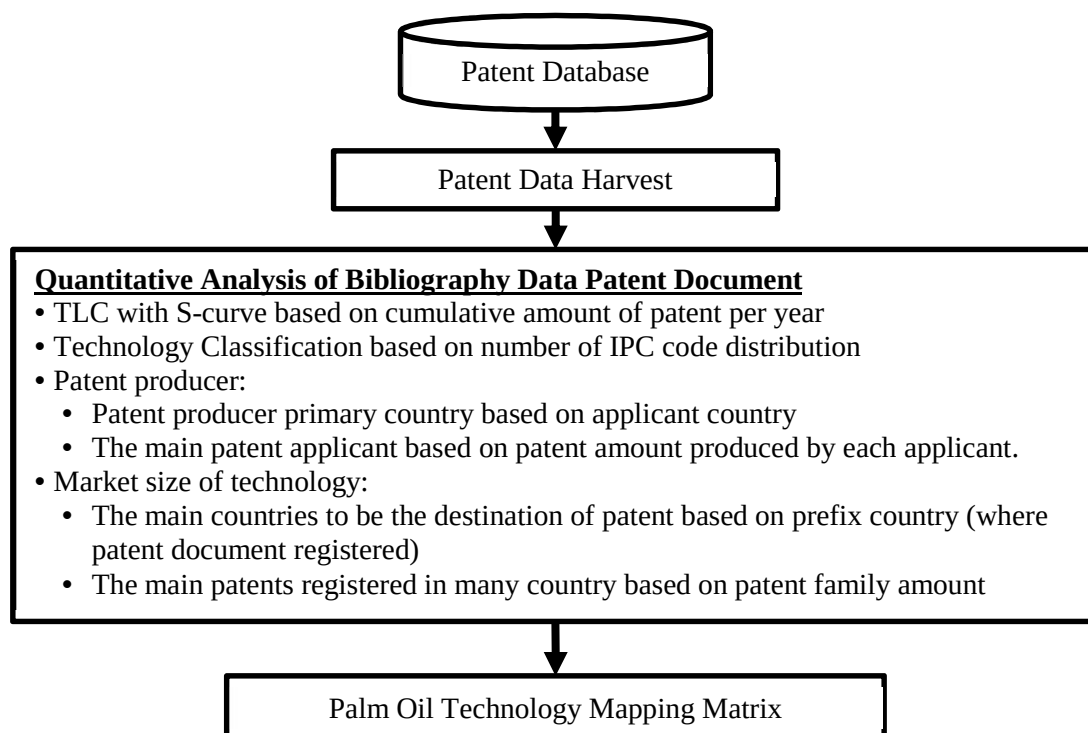


Figure 1. Research methodology.

3.2. Limitiations

Indonesian patent documents contained in Patent Inspiration database was in Bahasa Indonesia, so it was not included in worlds' palm oil patent data processing. Analysis of Indonesian patent data not carried out by Patent Inspiration Software are applicant country analysis, prefix country analysis, joint patent application analysis, and patent family analysis.

The searching using keywords “palm oil” or “oil palm” or “palm kernel” on the field filter “title” were affect a narrower scope of search results, which is specifically to palm oil technology starting from its cultivation to palm oil raw material processing (CPO and PKO), not including the technology to produce palm oil derivative products or palm oil products utilization in various other field of technology.

4. Result and Discussion

4.1. Palm oil technology life cycle

Patent data have become the source of information that can be used to explore technology changes and development [26-28]. Patent data in terms of technology trend can be used to predict technology life cycle (TLC) with the S-curve model approach build by utilizing cumulative number of patent registration each year [25-28]. Ernst [26] explained the four TLC stages as presented in figure 2, namely new technology (emerging), growth, maturity and saturation.

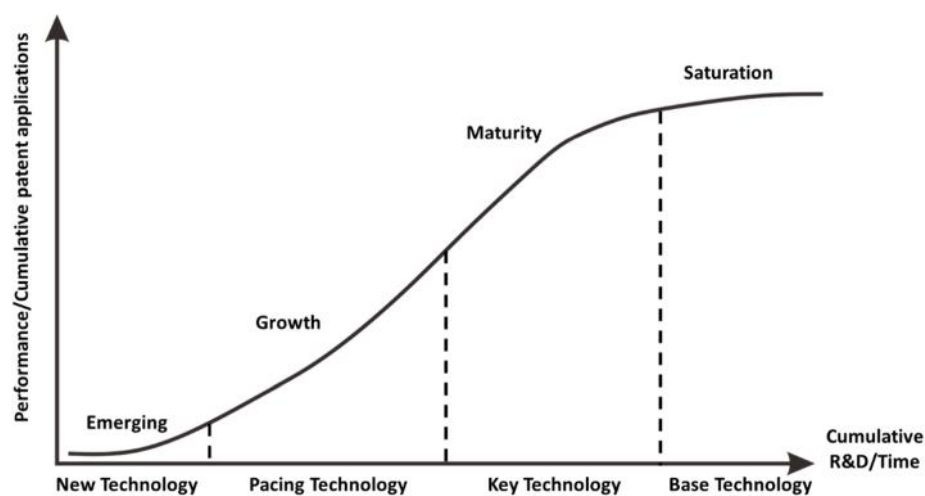


Figure 2. The TLC S-curve concept [26].

The first stage of technology development exhibit the effect of competition and integration of a product or a lower process [29] and patent request application growth still indicated a small number [30], on the other hand the number of patent application continue to increase [29]. During the growth stage, competition effect high [29] and the growth characteristic is exponential or rapidly [30]. On maturity stage, some technology will be appear as primary technology and having a high competitive impact in the market, the number of patent application relatively stabilized and tends to decrease [29]. The saturation stage indicates no further growth existed [30] and the number of patent application shows a significant decrease trend [29].

Based on TLC concept, palm oil technology development generally still being on the growth stage. The S-curve graph of worlds' palm oil technology development (Patent Inspiration database) and Indonesia (DGIP database) exhibit an increase in the cumulative number of patent registration since 1997 to 2016 (Figure 3 and Figure 4). Generally, the trend of worlds' palm oil technology development as well as Indonesia were being at the growth stage, meaning still provides very good opportunity for invesment and conducting palm oil research and development. Lee [31] stated that on the growth stage there will be found many technology purchase and sale transaction, technology licensing process will be more aggressive and intellectual property (IP) protection will be required to prevent IP patent violations.

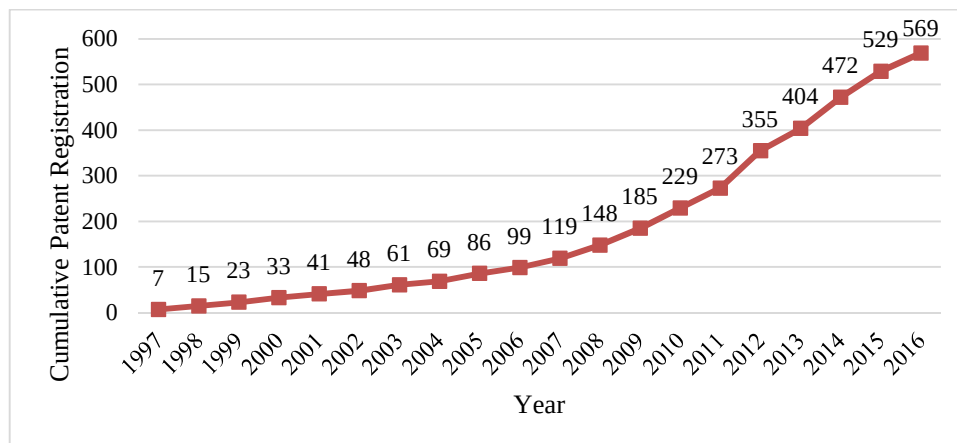


Figure 3. The number of cumulative palm oil patent registration worldwide based Patent Inspiration database.

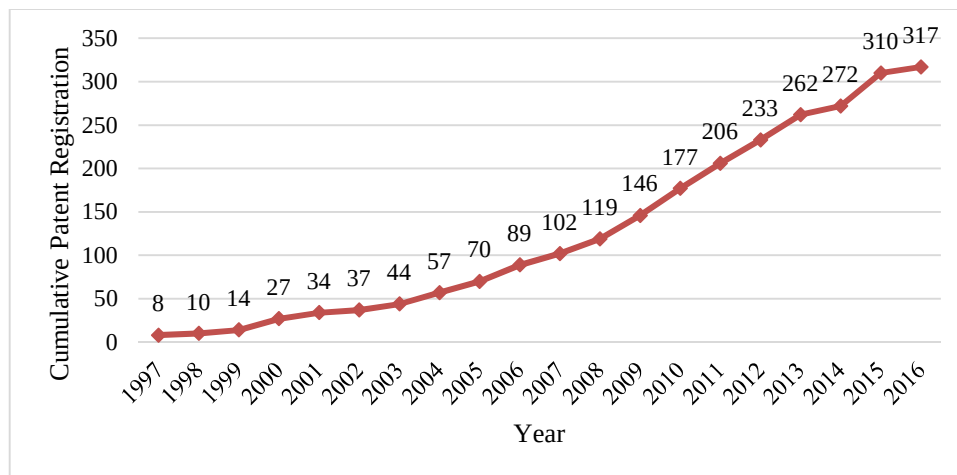


Figure 4. Cumulative number of Indonesia palm oil patent registration based on DGIP database.

4.2. The most developed palm oil technology group

The classification of palm oil technology conducted based on *International Patent Classification* (IPC) distribution. IPC is grouping/classifying field of patent internationally which was established by WIPO as a tool to obtain similar patent documents classification internationally [9]. One of IPC purpose as the basic of structuring technology statistical data which enable technology development assessment in various area [32]. IPC classification consists of four stages namely *section* (1st level, 1 digit), *class* (2nd level, 3 digits), *sub class* (3rd level, 4 digits), and *main group* atau *sub group* (4th level, > 4 digit), meaning the higher the level, the more specific the classification, however one patent can consists of several IPC.

Technology classification based on IPC section and class will generate an unduly wide scope of technology. Some researches related to technology classification based on IPC, generally classify technology based on their sub class and/or IPC main group. Altuntas et al [25] and She et al [24] were using IPC sub class to classify technology, meanwhile Shuang and Yan [23] using IPC main group; while Leydesdorff et al [33] using IPC class and sub class. In this research palm oil technology classification was classified based on IPC main group.

Based on IPC main group, it was discovered that as many as 358 palm oil technology groups in the world which the top 10 technology classification presented in Table 4. Palm oil classification in

Indonesia based on IPC main group quite diverse, there were 393 IPC main group code of palm oil in Indonesia which the top ten technology classification presented in Table 5.

Table 4. Top ten palm oil classification in the world based on IPC main group.

IPC Code	Number of Patent	IPC Code Description
C11B1/00	82	Production of fats or fatty oils from raw materials
A23D9/00	54	Other edible oils or fats, e.g. shortenings, cooking oils
C11B3/00	49	Refining fats or fatty oils
C11C3/00	38	Fats, oils or fatty acids obtained by chemical modification of fats, oils or fatty acids, e.g. by ozonolysis
C02F1/00	25	Treatment of water, waste water, or sewage
C11B7/00	24	Separation of mixtures of fats or fatty oils into their constituents, e.g. saturated oils from unsaturated oils
C12P7/00	24	Preparation of oxygen-containing organic compounds
A61K36/00	19	Medicinal preparations of undetermined constitution containing material from algae, lichens, fungi or plants, or derivatives thereof, e.g. traditional herbal medicines
A23D7/00	18	Edible oil or fat compositions containing an aqueous phase, e.g. margarines
A01H1/00	18	Processes for modifying genotypes

Table 5. Top ten palm oil technology classification in Indonesia based on IPC main group.

IPC Code	Number of Patent	IPC Code Description
A23D9/00	7	Other edible oils or fats, e.g. shortenings, cooking oils
C11B1/00	7	Production of fats or fatty oils from raw materials
C11B1/04	6	Production of fats or fatty oils from vegetable raw material
C11B7/00	6	Separation of mixtures of fats or fatty oils into their constituents, e.g. saturated oils from unsaturated oils
A23D9/02	5	Other edible oils or fats, e.g. shortenings, cooking oils, characterised by the production or working-up
B27D1/04	5	Joining wood veneer with any material; Forming articles thereby; Preparatory processing of surfaces to be joined, e.g. scoring, to produce plywood or articles made therefrom; Plywood sheets
C05F5/00	5	Fertilisers from distillery wastes, molasses, vinasses, sugar plant, or similar wastes or residues
C12N15/82	5	Mutation or genetic engineering; DNA or RNA concerning genetic engineering, vectors, e.g. plasmids, or their isolation, preparation or purification; Use of hosts therefor, for plant cells
A61K36/889	4	Medicinal preparations of undetermined constitution containing material from algae, lichens, fungi or plants, or derivatives thereof, e.g. traditional herbal medicines, (Arecaceae, Palmae or Palmaceae (Palm family), e.g. date or coconut palm or palmetto)
B27N3/00	4	Manufacture of substantially flat articles, e.g. boards, from particles or fibres

The top ten palm oil technology classification based on IPC main group indicated specifically the technology that widely developed in 1997 to 2016 are the technology related to production of fats or fatty oils from palm oil raw materials and enzyme utilization for the synthesis of organic compounds (C11B1/00, A23D9/00, C11B3/00, C11C3/00, C11B7/00, A23D7/00, C11B1/04, A23D9/02, C12P7/00); treatment of liquid waste (C02F1/00) and fertilizer from palm oil waste (C05F5/00); palm oil cultivation and nursery (A01H1/00, C12N15/82); preparation of medicine from herbal ingredients (A61K36/00, A61K36/889); and palm oil biomass utilization for particle board (B27D1/04, B27N3/00).

The study conducted by WIPO indicated the most active technology which relevant to palm oil production in 2010 to 2015 is cultivation and nursery as well as pressing process and palm oil refining, while the trend of waste processing and exploitation heading to mattress/cushion development, composite material, adsorbent, filter and biomass fermentation [34].

Trend of the top 10 palm oil technology areas based on main group of IPC in 1997-2016 shows that processing technology to produce fats or fatty oils from palm oil is increasing (Figure 5). This means that the processing technology to produce fats or fatty oils from palm oil is still potential to develop by universities or R&D institutions.

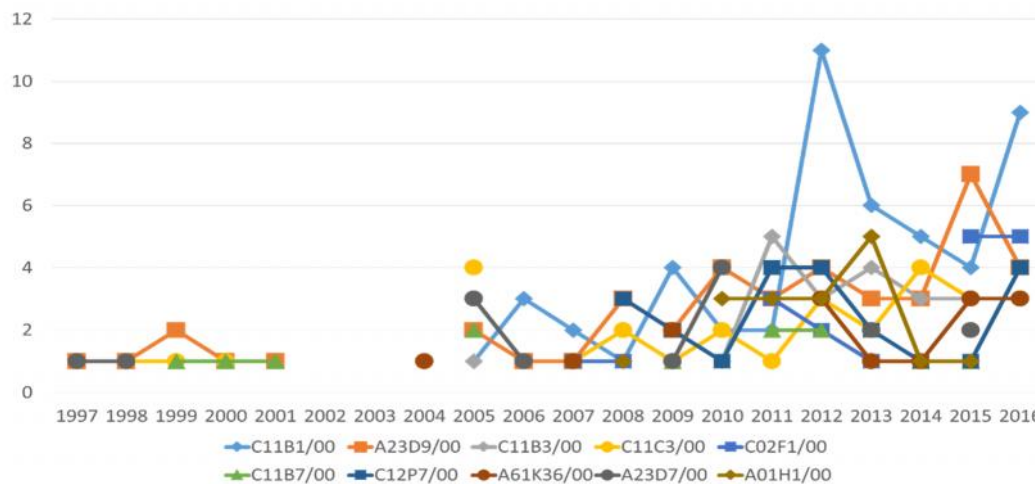


Figure 5. Trend of the top 10 palm oil technology areas based on main group of IPC in 1997-2016.

4.3. The biggest palm oil patent producer and applicant in the world and Indonesia

4.3.1. The countries dominating palm oil technology in the world and Indonesia. The distribution of palm oil patent application based on applicant country intend to reveal the producer of palm oil technology countries. This analysis will give a general description of the countries which become research and development center of a certain technology. Figure 6 describe that Malaysia is the biggest palm oil technology producer in the world, followed by Japan, China and so on. Malaysia being the biggest palm oil technology developer in the world is reasonable, considering they are the second best producer of palm oil in the world, with 37% from total world volume of palm oil production [3].

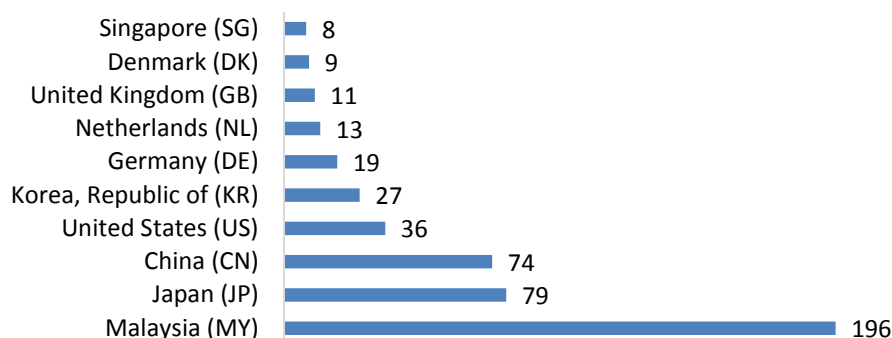


Figure 6. Top ten countries of palm oil patent producer in the world (applicant country).

Palm oil patent application data in Indonesia indicates most of palm oil patent applicant registered in Indonesia (51.70%) came from abroad, palm oil patent applicant who trully comes from Indonesia only as much as 48.30% (Figure 7). The biggest countries who registered palm oil patent to Indonesia were

Malaysia (32,39%) and Japan (6.82%). The data shows that most palm oil technology implemented in Indonesia came from abroad, especially Malaysia and Japan. BPD PKS [3] stated that Indonesia still have a big task to pursue its backwardness from Malaysia, which have been the benchmark all this time in terms of palm oil industry development and CPO downstream technology.

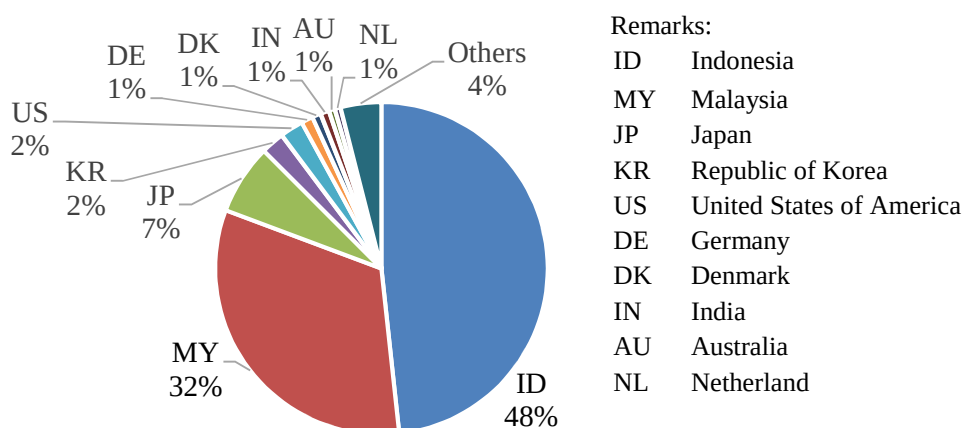


Figure 7. Top ten (10) palm oil patent applicant countries in Indonesia.

4.3.2. *Applicants from companies dominated palm oil patent in the world and Indonesia.* Patent applicant analysis will show who the main patent applicant in the field of technology being studied. The biggest patent applicant in a technology field expressed that those applicants are the main technology provider and also potential user of the technology at once. Patent applicant analysis of palm oil in the world studied in this research categorized into three categories, namely category of company, academic and individual.

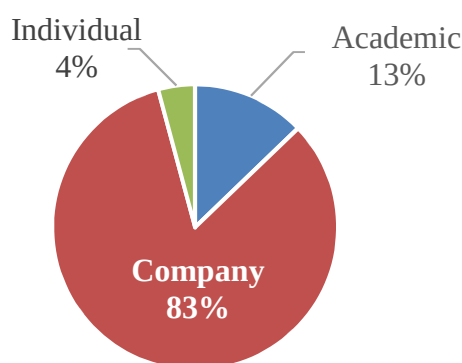


Figure 8. Percentage of palm oil patent applicant based on category of company, academic and individual.

Palm oil patent applicant data show that 83% of palm oil patent applicant came from company and 13% came from academic (Figure 8). The biggest palm oil patent applicant is Malaysian Palm Oil Board (MPOB) as many as 64 patent or owned a share of 5.83% from total applicants (Figure 9). The company has an interest in protecting its technology with a patent system because patents as intellectual assets play an important role in business performance and economic growth [35] and allow business cooperation between companies [36].

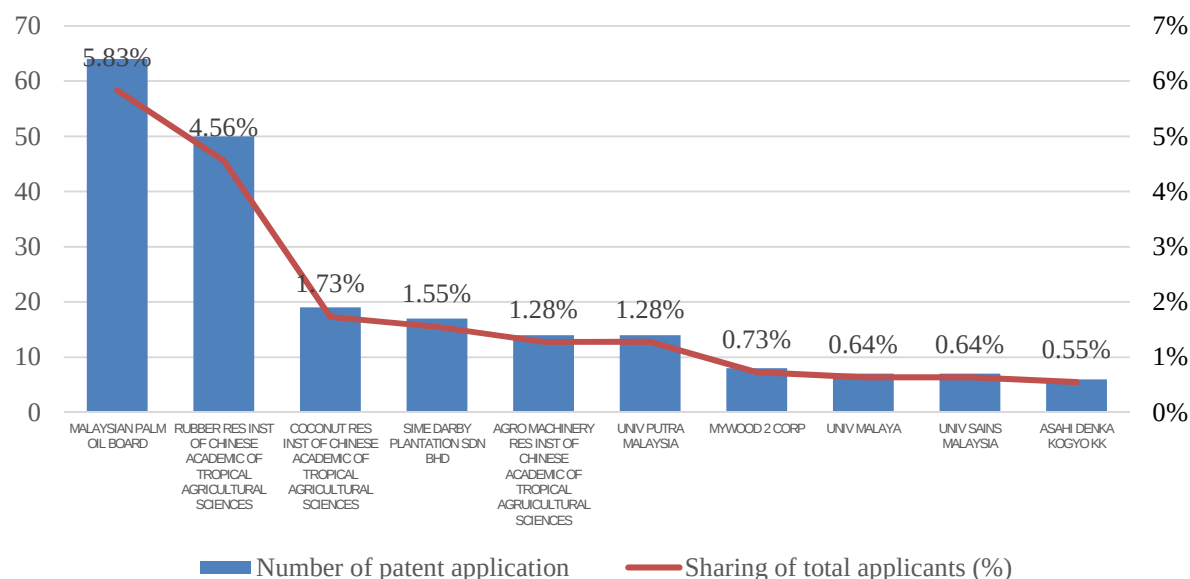


Figure 9. Top ten palm oil patent applicant in the world.

Patent data registered in Indonesia presented that the top ten palm oil patent applicant placed two patent applicant from Malaysia with patent amount reaching 53.85%, meanwhile patent application from eight patent applicant who came from Indonesia only reached 46.15% (Table 6). The number of patent application from MPOB reached 47.86%, showing a significant difference compared to patent application from other patent applicant. Those data truly define the statement of BDPKPS (2016) that Indonesia still have a big task to pursue its backwardness over Malaysia, who have been the benchmark in terms of palm oil industry development and CPO downstream technology.

Tabel 6. Top ten biggest palm oil patent applicant in Indonesia.

No	Name of Patent Applicant	Number of Patent
1.	Malaysia Palm Oil Board (MY)	56
2.	Bogor Agricultural University (ID)	13
3.	Indonesian Institute of Sciences - LIPI (ID)	10
4.	Yusuf Abdul Gani (ID)	9
5.	Sime Darby Malaysia Berhad (MY)	7
6.	Research Institution of Riau University (ID)	5
7.	University of Indonesia (ID)	5
8.	Agency for the Assessment and Application of Technology - BPPT (ID)	4
9.	Bayu Himawan, ST SE MM MM-SI MComm (ID)	4
10.	LPPM Sebelas Maret University (ID)	4

Based on the data analysis of patent applicant, it can be assumed that the institution who has most of palm oil patent application has strong applicative research in the palm oil sector, for example MPOB in Malaysia and Bogor Agricultural University (Institut Pertanian Bogor/IPB) in Indonesia. Other data that support the strength of palm oil research in an institution is non-patent publication (Scopus indexed publications), which shows that MPOB is among the top 10 palm oil publication producers in the world (596 publications). While in Indonesia, IPB is the largest Scopus indexed publication producer in the field of palm oil (152 publications) [37]. These institutions can be used as a reference for sources of palm oil technology or for research collaboration.

4.3.3. Joint patent application of higher education institution and company. Collaboration or cooperation intertwined between higher education institution with a company can be seen on joint patent application data. Joint patent application between higher education institution with a company indicates an ongoing research cooperation process between higher education institution with industry, furthermore expected to become technology shifting from higher education institution to industry or vice versa. Figure 10 presented that only 21 patent application submitted jointly between higher education institution and company, or only as much as 3.02% of 695 palm oil patent application. The data indicates that research cooperation between higher education institution with industry still needs more improvement.



Figure 10. Joint patent application between higher education institution with company.

4.4. Market size of palm oil technology

Patent rights are territorial, which only applies in the territory of the country where the patent is registered. Thus, to obtain patent protection in several countries or regions, patent owners must submit patent applications in each of countries or regions [38]. Filing patents in several countries is a business decision that requires careful consideration that is closely related to the target of implementation of the invention. There are several factors that need to be considered for filing patent applications in several countries, including demand and markets for inventions and the possibility of invention can be implemented in the destination country [39].

4.4.1. Palm oil patent application destination country. Analysis of patent registration country origin (Prefix Country) conducted by discovering the application destined area or targeted area of technology implementation. Based on prefix country analysis, discovering that China, Malaysia, United States of America, Japan and United of Kingdom are the main countries to be the destination of palm oil technology implementation in the world (Figure 11). Those countries are the targeted or market share of palm oil technology implementation.

Patent registration through WIPO of 18% is patent registration through Patent Cooperation Treaty (PCT) system, which enable to apply patent registration to many countries at once or the same time by a single registration internationally. Therefore, it would be difficult to identify one by one the countries which become patent registrations' destination through WIPO or PCT system, so that the patent registration through WIPO is grouped separately.

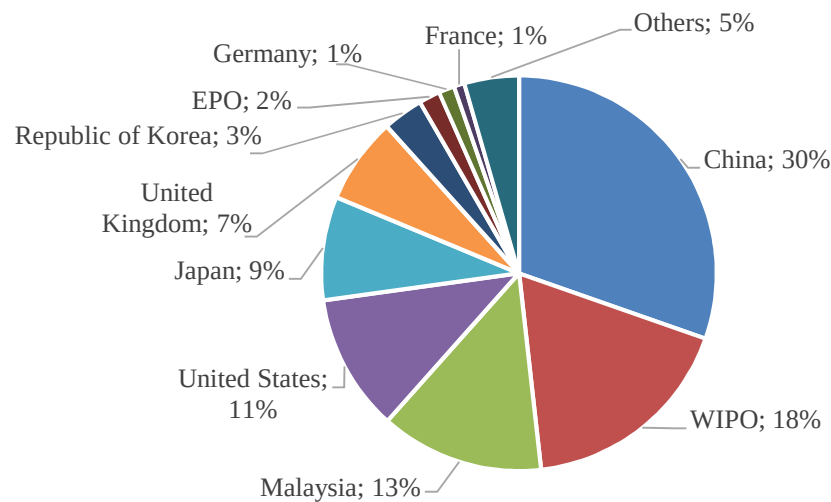


Figure 11. Palm Oil patent application destination country.

4.4.2. Patents with the biggest market size. Patent family is the sum of all patents registered in various countries either directly or indirectly connected with the same application which can be use to identify patents' value [40]. Patent family sum analysis can be use to measure market size of each invention or patent [41]. Formally, patent family covers patent application submitted in various country which interconnected to each other or several priority application [5]. Putnam [42], Harhoff et al [41] as well as Van Pottelsberghe and Van Zeebroeck [43] discover a positive correlation between patent value with the number of countries in which the patent protected for the same invention. Patent family could become a simpler indicator to measure market size of a technology. Table 7 presented 10 patents that possess the biggest patent family in the field of palm oil and the countries of its marketing area.

Table 7. Top ten palm oil family patents with the highest number of family and market area.

Patent Publication Number	Family Size	Patents' Title	Market Area
US5932275A	24	Palm kernel oil blends	United States of America, Eropa, Australia, Czech Republic, Jepang, Kanada, Cina, Brazil, New Zealand, South Africa, Singapura, Rusia, Jerman, Spanyol, India, Malaysia, Argentina, Austria, Kolombia, Hungaria, Norwegia, Turki, Ukraina
US2005069620A1	15	Trans free hard palm oil fraction, trans free non-hydrogenated hard structural fat and fat blends and methods	Eropa, United States of America, Kanada, Australia, Jepang, Cina, Jerman, Singapura, Spanyol, Austria, Denmark, Malaysia
US4004041A	14	Production of liquid edible oil from palm oil or similar oils	Belgia, Jerman, Belanda, Swedia, Jepang, Perancis, Inggris, Kanada, Italia, Swiss, Australia, Denmark, Israel

Patent Publication Number	Family Size	Patents' Title	Market Area
US2009155434A1	13	Process for production of highly enriched fractions of natural compounds from palm oil with supercritical and near critical fluids	Eropa, WIPO, Cina, Jepang, Meksiko, Jerman, Brazil, Malaysia, Austria, Spanyol, Hongkong,
US2010138951A1	12	Methods of producing haploid and doubled haploid oil palms	WIPO, Australia, Eropa, Cina, African Regional Intellectual Property Organization (ARIPO), Colombia, Costa Rica, Ecuador, Brazil, India
WO9213453A1	12	Herbicides for citrus, sugarcane, oil palm and the like	Australia, Cina, Eropa, Afrika Selatan, Jepang, Selandia Baru, Jerman, Spanyol, Kanada, Meksiko
WO2012108756A1	11	Optimising the utilisation of renewable energy from biomass resources in the palm oil industry	Inggris, Costa Rica, Dominican Republic, Meksiko, Peru, Ekuador, African Regional Intellectual Property Organization (ARIPO), Brazil, Guatemala
US5567670A	10	Herbicides for citrus oil palm, rubber and other plantation crops	WIPO, Australia, Cina, Afrika Selatan, Eropa, Brazil, United States of America, Kanada, Israel
US2014303389A1	10	Palm oil enriched in unsaturated fatty acids	WIPO, Australia, Kanada, Eropa, Cina, Jepang, Meksiko, Rusia, Brazil
WO2013012311A1	10	Method and apparatus for energy-efficient operation in the sterilization of oil palm fruit	ARIPO, Inggris, Kolombia, Dominican Republic, Meksiko, Costa Rica, Ekuador, Peru, Brazil

4.5. Palm oil technology mapping matrix

Palm oil technology condition and development map in the world and Indonesia can be organized briefly with a matrix in accordance to the analyzed aspects (Table 8). The matrix organization will simplify the observation of palm oil technology development based on patent information analysis.

Tabel 8. Palm oil technology matrix map based on patent information analysis.

No.	Analyzed Aspects	Map of Palm Oil Technology Condition and Development	
		World	Indonesia
1.	Technology Life Cycle	The trend of palm oil technology development is increasing and being at the growth level	The trend of palm oil technology development is increasing and being at the growth level
2.	Technology classification	• There are 358 technology group based on IPC main group code • The most developed technologies are the technology of production process of fats or fatty oils from palm oil raw materials and enzyme utilization for the synthesis of organic compounds; processing or treatment of palm oil wastewater; processes for modifying genotypes; and preparation of medicine from herbal ingredients	• There are 393 technology group based on IPC main group code • The most developed technologies are the technology of production process of fats or fatty oils from palm oil raw materials and enzyme utilization for the synthesis of organic compounds, fertilizer from palm oil waste, mutation or genetic engineering, preparation of medicine from herbal ingredients, and palm oil biomass utilization for particle board.

No.	Analyzed Aspects	Map of Palm Oil Technology Condition and Development	
		World	Indonesia
3.	Patent Producer	- The biggest palm oil technology producer in the world is Malaysia 83% palm oil patent applicant came from company and 13% of them came from academic - The biggest palm oil patent applicant is Malaysian Palm Oil Board (MPOB) (28.20%) - Collaboration between higher education institution with company is only 3.02% of 695 palm oil patent application.	51.70% palm oil patent applicant registered in Indonesia came from abroad - The biggest countries who submit the most registration of palm oil patent to Indonesia are Malaysia (32.39%) and Japan (6.82%). 47.86% palm oil patent application in Indonesia submitted by Malaysian Palm Oil Board (MPOB)
4.	Market size of technology	- China, Malaysia, United States of America, Japan and United Kingdom are the primary countries to be the destination of palm oil technology implementation in the world - Palm kernel oil blends (US5932275A) is the patent with the biggest market area registered in 24 countries.	Data not available

5. Conclusion

Palm oil technology mapping result based on patent information analysis in this research show palm oil technology both in the world and Indonesia being on the increasing trend or growth level, meaning still offering very good atmosphere for investment and conducting palm oil research and development. The most developed technologies in 1997 to 2016 are the technology of production process of fats or fatty oils from palm oil raw materials and enzyme utilization for the synthesis of organic compounds; treatment of liquid waste and fertilizer from palm oil waste; palm oil cultivation and nursery; preparation of medicine from herbal ingredients; and palm oil biomass utilization for particle board. This study recommends the processing technology to produce fats or fatty oils from palm oil to be developed by universities or R&D institutions.

Malaysia through *Malaysian Palm Oil Board* (MPOB) become the biggest palm oil technology producer in the world (28.20%), meanwhile in Indonesia most (51.70%) of palm oil patent applicants came from abroad. Palm oil patent applicant data in the world shows that 83% of palm oil patent applicant came from company (industry) group and the low number of joint patent application of Higher Education Institution-industry (3.02%) indicates that research cooperation of Higher Education Institution-industry still need more improvement. Prefix country analysis indicates that China, Malaysia, United States of America, Japan and England are the primary countries to be the destination of palm oil technology implementation in the world.

Mapping result of palm oil technology condition and development in the world and Indonesia which is conducted in this research can be positive input for Higher Education Institution, R&D institution as well as policy maker in organizing policy, conducting research and development activity, and developing research and business cooperation. Technology technical information contained in patent document can be utilized as references to generate applicative researches in accordance to industry requirements.

In this research, searching limitation on the field filter "title" affect narrower search result scope, which is specifically for technology cultivation, preparation of palm oil raw material (CPO and PKO) and waste treatment, not including the technology which produces palm oil derivative products or utilization of palm oil product in various other fields of technology. Therefore, further research still need to conduct with a wider scope of search, which based on market research report by Technavio which describing the existence of shifting phenomena from palm oil technology requirement heading to

derivative research and palm oil utilization, for example oleochemistry industry and cosmetic products. Future research needs to compare the patent information analysis with scientific publications analysis and case studies of recent developments from R&D institutions or universities.

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