

Sustainable Supply Chain Performance Improvement for Patchouli Oil's Agroindustry: A Systematic Review and Research Agenda

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Abstract. Patchouli oil is an essential oil that has become one of the agricultural leading commodities in Indonesia. The problems that occurs in the patchouli oil agroindustry is the existence of a complex and long supply chain system. An alternative problem solutions are needed includes supply chain improvement models and strategies. This article summarizes some previous research on essential oil and assessment of sustainable supply chain's performance. The subject of publication evaluation used a systematic literature review that applied the meta-analysis methods (PRISMA), with a total of 131 articles reviewed in more depth. Sustainability studies are divided into four groups ranging from the one to four pillar sustainability. The level of comparative and criticize resulted that over the last ten years, the percentage of research that deals with sustainable supply chains was still very minimal and the commodities of essential oil were not included in it. Patchouli oil research has been carried out in the fields of product benefits, production improvement, process technology, and product composition or characteristics. Research developments have not yet been discussed on the topic of strategies to improve the performance of sustainable patchouli oil supply chains.

1 Introduction

Plant elements such as leaves, flowers, fruits, seeds, stems, skin, and roots are the source of essential oils, which are aromatic compounds found in plants. Essential oils are used as industrial raw materials for essence, flavors and fragrances [1]–[3]. There are several types of essential oils produced by Indonesia, namely clove oil, citronella, patchouli, nutmeg, vetiver, and eucalyptus [4].

The demand for various essential oil products is increasing not only for the local market but also abroad as exported products [5]. Indonesia is recorded as one of the world's largest suppliers of essential oil raw materials [4], but the fluctuation in export value indicates that

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there are problems in the essential oil agroindustry [6]. In addition, there are weaknesses in the long and ineffective supply chain system from upstream to downstream. The complex supply chain system causes fluctuations in essential oil prices. The distribution network used for marketing has an indirect impact on the imbalance between supply and demand for essential oils. Intermediaries in the essential oil supply chain result in low bargaining positions for farmers and distillers. Intermediaries are still used in product marketing, which result in long marketing distribution and ineffective supply chain performance [2]. In a study it was concluded that without intermediaries in the marketing of essential oils, the price received by distillers increased by 88.33% [7]. The complexity of the agro-industry also needs to be supported by an integrated performance measurement system, not only performance measurement within an organization but also between actors along the supply chain [8]. Additionally, it is expected that the integration will facilitate access to market data and contribute to the achievement of price stability. Good governance in the essential oil agroindustry will facilitate the flow of market information between supply chain actors, such as the establishment of cooperatives will improve supply chain performance [9]. Another problem with the essential oil industry related to downstreaming is the limited number of industries that process crude essential oils into downstream products or derivatives [1].

The problem of essential oils in general is also reflected in patchouli oil. Patchouli oil is one of the largest exported commodities, from a total global demand of 1200-1500 tons/year, ninety percent of the world's patchouli oil demand comes from Indonesia [2], [10]. Patchouli and nutmeg oils each have a world market share of more than 90%, while clove leaf oil and its derivatives dominate more than 70% of the world market share [4].

The increase in the volume of patchouli oil exports in recent years has not been supported by the amount of production and productivity in the patchouli oil agroindustry. The development of the area of patchouli planting tends to fluctuate, with an average development from 1990 to 2022 of 6.93%. The average production development from 1990-2022 was 6.79% and the average from 2016-2022 was 3.86%. For the average productivity growth in 2016-2022 was is 3.10% [11]. From the data from the last five years, a sharp decline occurred in the amount of production and productivity in 2021 as seen in **Fig. 1**.

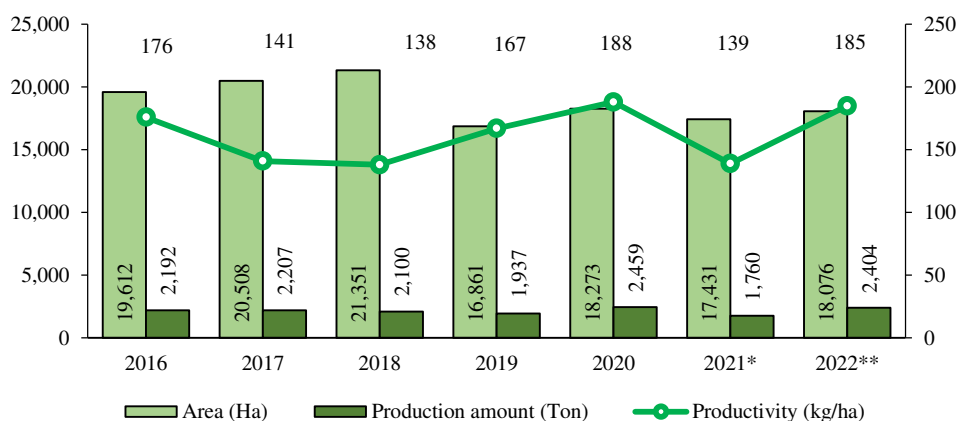


Fig.1. Area, production amount and productivity of patchouli oil [11]

The data range for the quantity of patchouli oil production shown in **Fig. 2** is the minimum and maximum production data issued by the Indonesian Essential Oil Council.

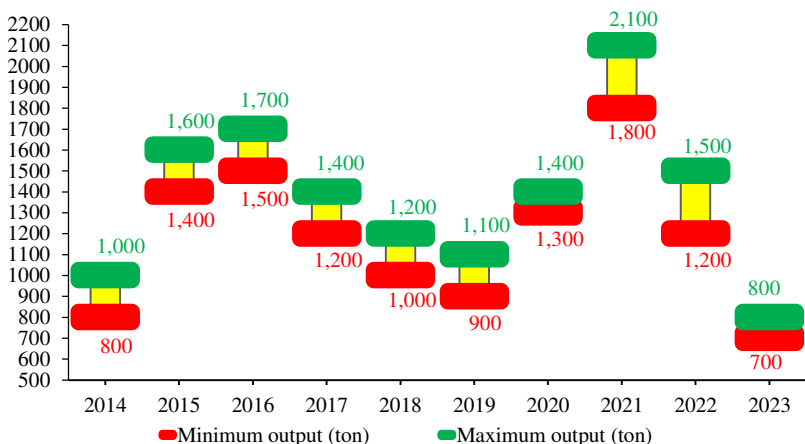


Fig.2. Range of patchouli oil production amounts [12]

The complexity of the patchouli supply chain also causes other problems, namely non-transparent and fluctuating patchouli oil prices, and non-continuous product supply [13] and the underdevelopment of the industry producing downstream products from patchouli oil. Domestic patchouli prices as an export commodity depend on international prices, in the patchouli oil supply chain, prices are controlled by exporters. The more complex and longer the supply chain, the more diverse the patchouli oil prices are for upstream actors, so that the welfare of patchouli farmers depends on price fluctuations. The varying prices of patchouli oil also affect the quantity of patchouli oil available on the market. The amount of patchouli oil stock increases when the price increases and vice versa [14].

Farmers will start planting patchouli plants when patchouli oil is highly priced, but if the price of patchouli oil decreases, the land will be planted with other crops. In the patchouli oil agro-industry supply chain, there is an industrial cooperation contract between industry actors, exporters and technology providers which causes domestic industry players to have to purchase raw materials from their technology providers. This hinders the development of downstream products domestically. The important role of this patchouli oil commodity needs to be considered and to maintain its availability both on a local scale and for export needs as well as to increase the added value and competitiveness of patchouli oil derivative products, a strategy is needed to improve the performance of a sustainable supply chain starting from crude patchouli oil to downstream patchouli oil products. This sustainable supply chain performance improvement strategy will support government decisions at the strategic level, then its implementation can be grouped at the tactical and operational levels. Sustainable supply chain performance improvement is in line with the policy direction to achieve development goals and targets issued by the Ministry of Agriculture [15]. In addition, improving the performance of the sustainable patchouli oil supply chain also refers to the Sustainable Development Goals, by considering four pillars, namely the development of legal and governance system, the development of the environment, the development of the economy, and the development of social.

By considering all these factors, this study will answer how research on essential oils has been developed, how research on sustainable supply chains on essential oil commodities has developed and how research has developed related to improving the performance of sustainable supply chains in the patchouli oil agroindustry. A literature review was carried out systematically to obtain an overview of developments in essential oil research, developments in sustainable supply chain research on essential oil commodities and developments related to improving performance in sustainable supply chains in the patchouli oil agroindustry. This sustainable supply chain study was carried out

starting from raw patchouli oil to downstream products by involving supply chain actors ranging from farmers to the patchouli oil processing industry. This study is expected to be a basis for research to produce models and strategies for improving the performance of sustainable supply chains in the essential oil agroindustry, especially patchouli oil.

2 Research methodology

2.1 Research framework

This study focuses on several categories that are interrelated with each other. The first category focuses on articles about supply chains, especially sustainable supply chains. From the study in this first category, the relationship between supply chains, sustainable supply chains and patchouli oil agroindustry will be analyzed. The second category focuses on articles about essential oils and patchouli oil. From the study in this second category, the results of previous studies on the relationship between sustainable supply chains and patchouli oil commodities will be analyzed. The last category focuses on articles about patchouli oil downstreaming. The analysis of this last study is the same as the second study, but it looks more at the relationship between patchouli oil downstreaming and sustainable supply chains.

2.2 Systematic literature review flowchart and data analysis

In this study, collection and selection of papers are important stage in the Systematic Literature Review (SLR) stages that will be carried out. Data for this study were collected by methodically looking through relevant, peer reviewed academic journals. The journal articles collected are articles related to the research topic. SLR is used to identify, evaluate and synthesize existing knowledge on a particular topic. SLR allows a comprehensive assessment of relevant findings and their interpretation in relation to the research topic. SLR can also be conducted to examine previously conducted research and identify research gaps to help design our next research [16].

The determination of the research gap was also carried out in this study by analyzing data using vos viewer. The selection of journal articles used the same keywords as the stages carried out in the vos viewer application, namely the keywords sustainability supply chain, essential oil and or patchouli oil and downstream patchouli oil. Vos viewer is a software used to visualize publication data and analyze publication data in an easy-to-understand visual form. Data analysis that can be done from vos viewer is analysis of network, overlay and density. The network formed describes the network formed and divided into several clusters. The overlay formed describes the novelty of the research and the density describes the frequency of the research conducted. The preferred reporting items for systematic reviews and metaanalysis (PRISMA) approach was used in this study to finish the systematic literature review. The research flow following the PRISMA methodology is illustrated in **Fig.3**.

The database sources used in this study come from Scopus, Google Scholar and Web of Science. The articles that were successfully collected were 920 articles and then 131 articles were selected for further review. The criteria for selecting articles to be reviewed further were articles written in English and Indonesian, articles published with Scopus indexed and Sinta national indexed journal standards and articles published in 2013-2023. While the criteria for journal articles that were not selected were articles that already

existed (duplicates) and articles that could not be fully accessed in the journal article content. The stages of selecting or sorting articles that are not included for review are as follows :

1. Initial stage or identification stage of 144 duplicate articles and 179 articles that do not match the details of the discussion topic
2. Screening stage of 151 articles that are not included in journal articles, for example articles in proceedings, books or magazines, then 123 articles do not use Indonesian or English, then 114 journal articles cannot be accessed perfectly because they are not full papers and 78 journal articles are not included in quartile 1 (Q1) to quartile 4 (Q4) journal standards and also Sinta 1 or Sinta 2

The SLR stages carried out in this study follow the Summarize, Synthesize, Comparative and Critize stages.

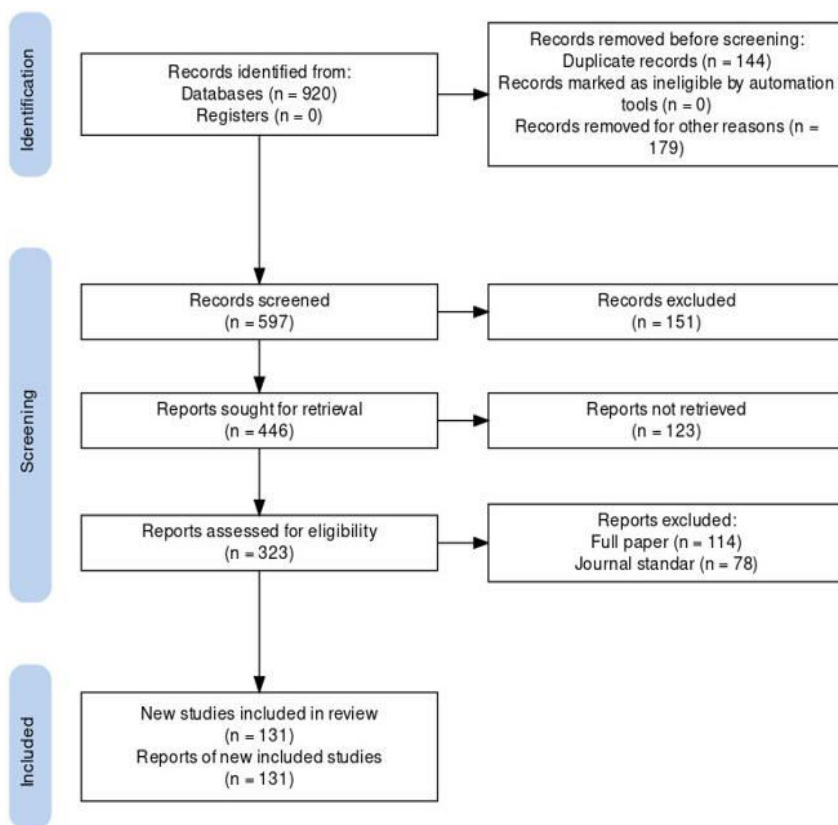


Fig.3. Systematic literature review flowchart, adapted from PRISMA

3 Result

3.1 Network formed as data analysis

The network formed from the keyword sustainability supply chain and or patchouli oil is illustrated in **Fig.4**. The clusters formed from these keywords are supply chain, supply chain management, life cycle, environmental impact and essential oil articles. There is no

3.2 Systematic Literature Review Stages

The first stage of this systematic literature review is the summarize stage. At this stage, a total of 131 articles to be reviewed are grouped based on the year of journal publication, the standard quartile group of the journal and the journal publisher. The distribution of the number of articles and the year of journal publication can be illustrated in **Fig.7**. The year of publication of the journal is grouped from 2013 to 2023.

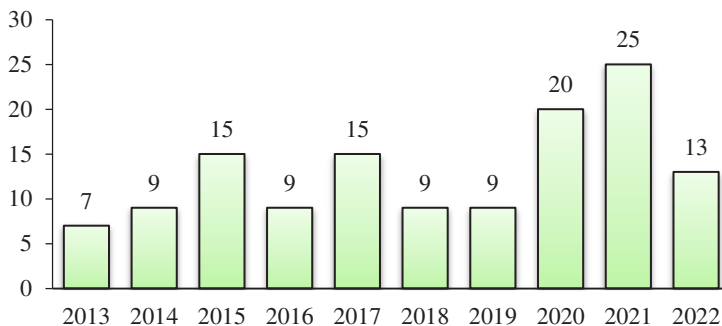


Fig.7. Number of articles per year

Articles submitted in 2022 as illustrated in **Fig.7** divided into Q1 journal standard that have been reviewed are [17]–[24], Q2 journal standard are [25]–[27] and Q3 journal standard are [28], [29]. Furthermore, at this summarize stage, journal articles are also grouped based on journal standards starting from Q1 to Q4 journal standards and also Sinta 2 journal standards. The grouping of journal standards can be illustrated in **Fig. 8**. From **Fig. 8**, it can be seen that the journals that were most successfully collected were articles from Q1 journal standard amounting to 69%, then Q2, Q3, Sinta 2 and finally articles from Q4 journal standard amounting to 1%.

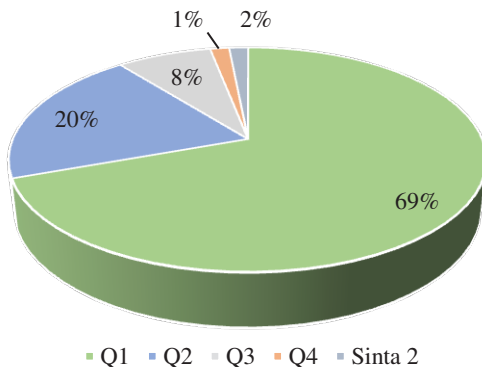


Fig.8. Distribution of articles based on journal standard

The grouping of journal publishers of the 131 collected articles can be illustrated in **Fig.9**. The journal publishers of the collected articles are journal of cleaner production, foods, international journal of production, supply chain management, international food and agribusiness, etc.

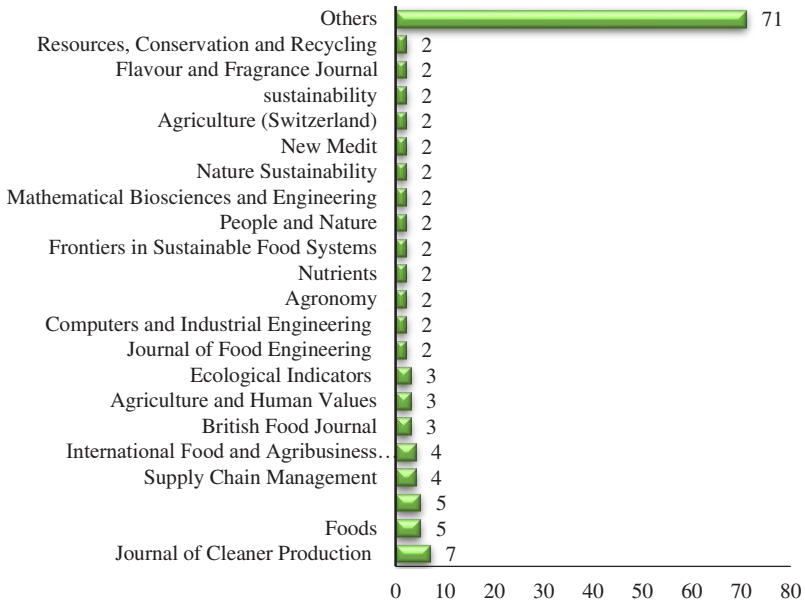


Fig.9. Distribution of articles by the publisher

The next SLR stage after the summarize stage is the synthesize stage. In the synthesize stage, the articles to be reviewed are grouped and clustered. The first grouping is done by dividing the focus of the Sustainability Supply Chain discussion into sustainability pillars, namely economic, social, environmental, governance or a mixture of these pillars. The grouping of the sustainability pillars can be illustrated in **Fig.10**. **Table 1** shows the division of sustainability pillars from various articles related to the topic of sustainability supply chain discussion

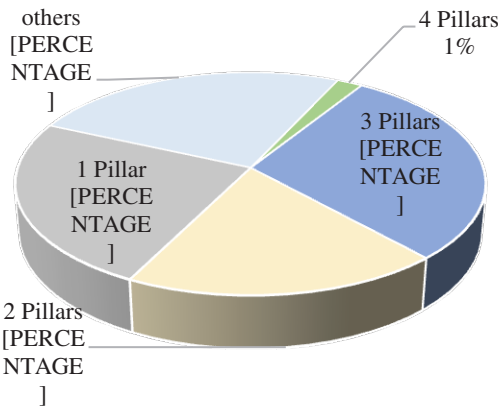


Fig.10. Distribution of articles based on sustainability pillars

Table 1. Dimension of sustainability pillars

No	Articles	Dimension of Sustainability			
		Economic	Social	Environment	Governance
1	[18], [30]–[32]	v			
2	[33], [34]			v	
3	[35]				v
4	[36]	v		v	
5	[20], [37], [38]		v	v	
6	[26], [27]	v	v		
7	[39]	v	v	v	v
8	[17], [19], [25], [40]–[49]	v	v	v	
9	[50]		v	v	v

Grouping based on commodities can be illustrated in **Fig.11**. The selected articles are grouped into agricultural/plantation commodities, fishery products, livestock products and special groups of essential oils.

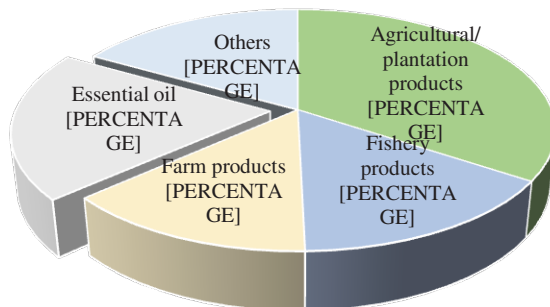


Fig.11. Distribution of articles based on commodity

The next grouping is grouping based on the system approach of the articles that have been collected and reviewed. Grouping based on the system approach will later be divided into hard system, soft system and soft system dynamic approaches. In **Fig. 12** we find that the soft system approach has the highest percentage of 46%, then the percentage of the hard system approach is 44% and the other 10% are not depicted using any system approach. The soft system dynamic methodology approach can be a research gap that needs to be explored more deeply regarding the sustainability of the supply chain in essential oil commodities.

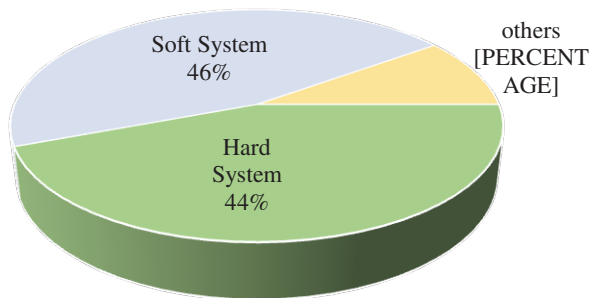


Fig.12. Distribution of articles based on system approach

At this SLR stage, the percentage of discussion topics formed from the reviewed articles is also seen as illustrated in **Fig. 13**.

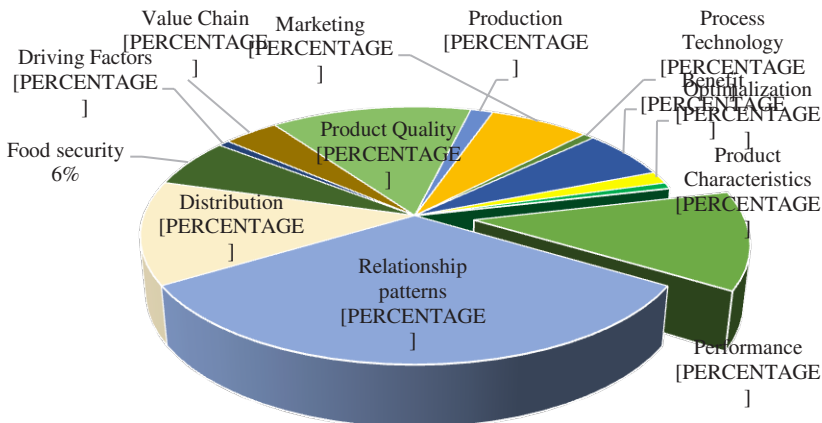


Fig.13. Distribution of articles based on discussion topics

Grouping of previous studies of essential oils and patchouli oil is also done at this stage to see the research topics that have been studied previously. **Table 2** shows the research topics of several types of essential oils other than patchouli oil, while **table 3** shows the research topics of patchouli oil that have been done. This grouping can be input for the next stage, namely the compare and criticize stage.

Table 2 Essential oil research

No	List Of Essential Oil	Research Topic	Research Methodology	Author
1	Essential oil in general	Effects of essential oil	Experimental studies in animals	[51]
2		Effect of essential oil	Different methods of treatment	[23]
3		Effect of essential oil	Literatur review	[52]
4		Marketing	System dynamic	[53]

Table 2 Essential oil research

No	List Of Essential Oil	Research Topic	Research Methodology	Author
5	Olive oil	Supply chain	Literature review	[54]
6		Supply chain	Qualitatif approach : in depth interview	[55]
7		Value chain	Review and study case	[56]
8	Tunisian olive oil	Supply chain	Fuzzy topsis	[49]
9	Oregano essential oil	Effect of essential oil	Experimental studies in animals	[57]
10	Eugenol and garlic essential oil	Effect of essential oil	Laboratory test : artemia salina test	[58]
11	Edible oil	Composition of essential oils	Analysis of image	[59]
12	Metha piperita essential Oil	Composition of essential oils	ATR-FTIR spectroscopy coupled with multivariate analyses	[60]
13	Lavender	Value chain	Bussiness model canvas	[61]
14	Cengkeh oil	Value chain	Qualitative approach	[62]
15	Calendula officinalis	Supply chain	Mixed integer linier programming, LCA method	[63]

Table 3 Patchouli oil research

No	Research Topic	Research Methodology	Author
1	Composition	Literatur Review	[10], [64]
2	Composition	Experimental studies	[65], [66]
3	Optimalization	Biotransformation	[67]
4	Production and Marketing	Data Envelopment Analysis (DEA)	[68]
5	Strategy	System Dynamic : Analisis SWOT	[69]
6	Production	System Dynamic	[18]
7	Process Technology	Experimental studies : Conventional hydrodistillation and Microwave-assisted Hydrodistillation	[70]
8	Benefit	Literatur Review	[69], [71]
9	Product characteristics	Experimental studies: Physical Test of Product	[72]

In the Comparative and Critize stages, all reviewed articles are compared and criticized in relation to the research topic. This stage refers to the outcome from the previous stages. The outcome are as follows :

1. Previous research that discusses sustainable supply chains by considering the 4 pillars is only 1%. The research focuses on agricultural commodities but does not explain the commodities in more detail.
2. Previous research discussing essential oil commodities is 20%. From this percentage, there is no research discussing sustainable supply chain performance.
3. Previous research has not used the soft system dynamic methodology approach.
4. Previous research with the topic of supply chain performance is 12%.
5. Previous research on patchouli oil commodities has not discussed the topic of models and strategies for improving sustainable supply chain performance, either in the form of crude or downstream products.

All SLR stages can be used as a basis for analysis to find research gaps and become a basis for developing further research that is expected to overcome problems that occur in the patchouli oil agroindustry.

4 Discussion

There are several potentials that can be developed for further research. The first potential for further research is research regarding assessing and improving the performance of sustainable supply chains in the patchouli oil agroindustry. As the results obtained from the SLR stage of previous research on the topic of performance assessment are still quite low, namely only 12% for all commodities reviewed in 131 journal articles, of which 12% there has been no assessment of supply chain performance in the patchouli oil agroindustry. Previous research that has been studied for essential oil commodities, amounting to 20%, has not discussed the assessment of sustainable supply chain performance, so research regarding the assessment and improvement of supply chain performance, especially the assessment of sustainable supply chain performance, is very necessary to be carried out. It is hoped that this research can overcome problems in the patchouli oil agroindustry, especially the main problem, namely the complex and long supply chain system. The complex patchouli oil agroindustry supply chain system is illustrated by the existence of several chains starting from farmers to patchouli oil users, either exporters or consumers, then back from exporters to importers or consumers abroad [5], [73], [74].

The second potential for further research is research into assessing sustainable supply chain performance which refers to the 4 pillars of sustainability, namely economic, social, environmental and governance. This improvement in supply chain performance is in line with sustainable development goals [15]. From the results obtained from the SLR stage of research which discusses the assessment of sustainable supply chain performance with the 3 pillars of sustainability, the highest percentage is 30 percent and the lowest percentage is in the assessment referring to the 4 pillars [39].

The problem of supply chain complexity in the patchouli oil agroindustry also gives rise to other problems, such as the problem of non transparent and fluctuating prices of patchouli oil, discontinuous product supply [13], [14], [73], [75] and the lack of industrial development which produces downstream patchouli oil products. These problems need to be addressed so that the availability of patchouli oil both on a local scale and for export needs can be maintained and the added value and competitiveness of patchouli oil derivative products can increase. Alternative problem solving that will be developed includes models and strategies for improving supply chain performance starting from products in the form of crude patchouli oil to downstream products. Designing models and strategies for improving supply chain performance using the Soft System Dynamic

Methodology (SSDM) approach can be a potential for further research. The SLR results show that there has been no previous research that discusses models and strategies for improving supply chain performance. The soft system approach has the highest percentage of all articles reviewed and there is no SSDM approach used in these articles. By considering the real conditions of the patchouli oil agroindustry and the complexity of the real problems that occur in the field, the SSDM approach is considered the most appropriate approach to be developed in further research and can provide solutions to the problems that occur. The SSDM approach consists of ten stages which combine two systems approach methods, namely system dynamics (SD) and soft system methodology (SSM) as a synergistic intellectual tool for the systematic study of complex situations [76]. The application of dynamic systems has been carried out in previous patchouli oil research related to the topic of identifying the strengths and weaknesses of agroindustry [67] and production policy [14]. This strategy to improve sustainable supply chain performance will support government decisions at the strategic level, then in its implementation at the tactical and operational levels.

5 Conclusions

All stages of SLR have been carried out dan resulted in the following conclusions. The first conclusion is over the past ten years, essential oil research has been conducted on product benefits, production improvements, process technology, and product composition or characteristics. Research development has not been discussed on the topic of strategies to improve the performance of a sustainable patchouli oil supply chain. The second conclusion is related to research on the topic of sustainable supply chain. Sustainable supply chains are still very minimal and the commodities of essential oil are not included in it. The final conclusion is that the topic of discussion of strategies to improve the performance of the sustainable patchouli oil supply chain has never been discussed before. Research that can be developed to overcome the main problems in the patchouli oil agroindustry is design model of supply chain performance improvement for sustainable patchouli oil agroindustry.

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