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Evaluation of Vegetable Oil Extraction Methods on Crude Oil Yields in Indonesia. Systematic Literature Review

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ABSTRACT
The method of extracting vegetable oils greatly affects the optimal yield and can affect the composition of the fatty acids that make up the triglycerides contained in the resulting oil. Systematic literature review method with research topics regarding the evaluation of the development of oil extraction methods for crude oil produced from 300 selected articles, then selected to become the following 100 articles into 25 relevant articles, obtained research data carried out to obtain optimum results is method Soxhlet extraction. From 25 articles, 4 articles were selected, which carried out optimization and follow-up on the oil results obtained, namely by purifying the oil and applying it to the product. This extraction method has not been developed on an industrial scale, only on a research or laboratory scale. The most widely used in the process of extracting oil on an industrial scale is the screw method, or known as the screw press.

KEYWORDS
Extraction; Method; Oil; Vegetable

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1. Introduction

1.1 Background

Vegetable oil is oil derived from plants as a substitute for fossil energy sources that can be produced sustainably; the source of vegetable oil comes from seeds and fruit flesh produced through an extraction process. At present, the extraction process that is developing in Indonesia on a research scale is using the soxhletation process, namely by carrying out the extraction process using a solvent. Vegetable oils are composed of triglyceride components and have good soluble properties in non-polar organic solvents [1]. Hot pressing refers to the seeds are roasted at a temperature above 105 ^{o}C, and the seeds are pressed at about 180 ^{o}C. Hot pressing is a prevalent method for oil extraction because of its high oil yield and low cost, but the micronutrient in edible oil will be damaged, and even causing the loss of other bioactive ingredients [2].

The extraction method of vegetable oil is very influential in producing optimum yields. It can affect the composition of the fatty acids that make up the triglycerides contained in the oil produced. Determining the composition of the fatty acids contained in the oil can be done by testing the fatty acid profile using the GC-MS method. There are numerous functional features present in oil having copious bioactive chemicals, and these functional properties might change depending on the extraction procedure used. This makes it difficult to extract the oil. The effects of different solvents, heat, and extraction times on the presence of different conjugated and free phenolic compounds in oil [3]. There is no set method for extracting oil that will offer the greatest amount of beneficial bioactive chemicals and antioxidants for health. [4]

The soxhlet extraction method (SE) has been used for a while and provides the highest yield. Nevertheless, it is a heat- and time-intensive method that changes the oil's nutritional qualities. The demand for virgin edible oils is growing

right now since they may be extracted using techniques that need little or no heating, such as cold or screw press extraction method (CPE) and mechanical shaking extraction method (MSE), without altering the chemical structure of the oil.

Unrefined oils from the CPE process are rich in phytosterols and phenolic compounds, but their oil output is lower than that of the SE method. With the MSE approach, the solvent and sample are fully homogenized over a longer period of time by mechanically shaking. Selective reactivity allows the components of the sample to dissolve in the solvent. However, it is slower than CPE and SE techniques. [5]. Vegetable oil contains more types of unsaturated fatty acids compared to saturated fatty acids, which are usually obtained from animal oils. Some of the functions of vegetable oil are for cosmetic and food industry raw materials that contribute to health.

1.2 Objective

In this study, the extraction method was evaluated to produce crude oil or crude oil to produce the maximum yield and pay attention to the main oil content.

2. Research Methods

This research was conducted using a systematic literature review approach by compiling research questions and searching for articles using keywords on Google Scholar using Harzing's Publish or Perish (Windows GUI Edition, Tarma Soft Ltd) application for 300 articles. Then an analysis was conducted using VOSviewer (Nees Java van Eck and Ludo Waltman) to determine the research topic's relationship. Data processing uses tables to see developments and comparisons of research that has been conducted from 2017-2023.

Several research questions were developed for GAP from the development of research scientists in the field of fats and oils in the agro-industry sector. There are also research questions compiled in research, namely 1). How far has the oil extraction method developed from previous studies? 2). What are the variables used to support the extraction results? 3). The analytical method used, 4). application and recommendation of crude oil in agroindustry.

3. Results And Discussion

3.1 Cluster Analysis

This research was carried out by compiling a conceptual framework in 3 research clusters with the aim of classifying research stages related to the crude oil extraction method. From the literature, it was found that 3 clusters influenced and the purpose of conducting research related to oil extraction. In Figure 1, it can be seen that the clusters discussed in this study are Cluster 1, covering the exploration of sources of vegetable oil, namely looking at several sources of vegetable oil, and Cluster 2. Covering the treatments and variables that affect the ecstasy method and Cluster 3, the yield resulting from the extraction and follow-up methods follow-up, and research recommendations.

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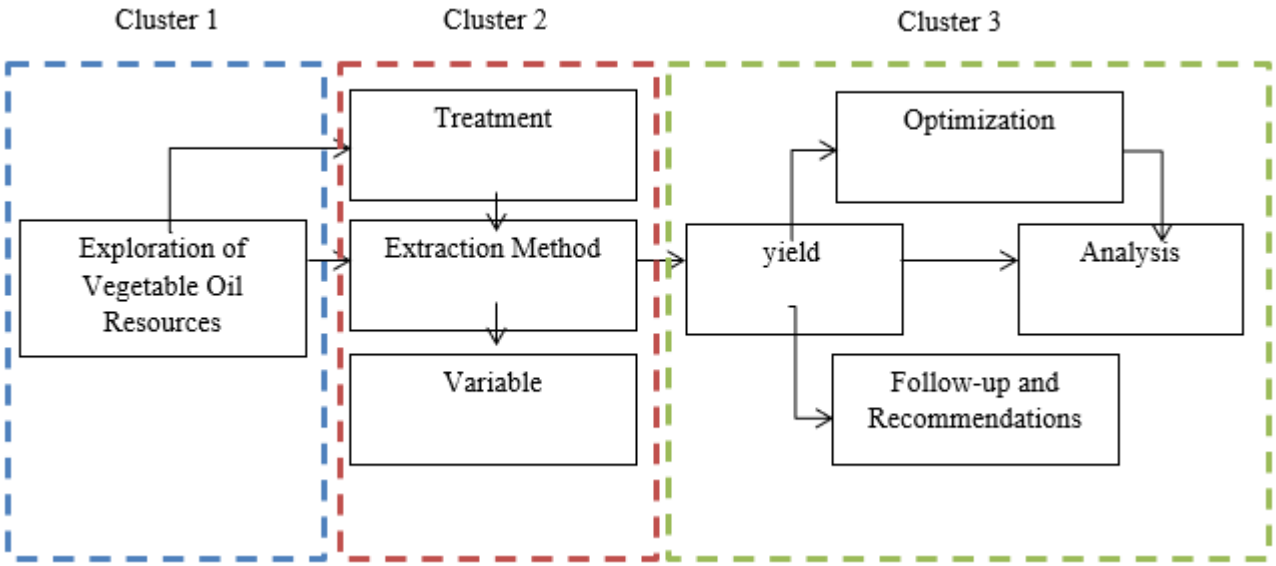

Figure 1. Research Framework

3.1.1 Cluster 1

a) Sources of raw materials for vegetable oil have not been thoroughly explored,
b) sources of vegetable oil derived from seeds and fruit are only studied from plants that are still common
c) it is necessary to explore specific/special/endemic plants that also have the potential to know the oil content so that they can be developed.

3.1.2 Cluster 2

a) The preparatory stages carried out by several studies are still not perfect. Some studies still use solar heat and ovens to dry raw materials. This does not give optimum results at the preparation stage.
b) The oil extraction process, which is still being carried out with several studies, still uses the old method developed by Franz Von Soxhlet
c) The Soxhlet extraction process uses non-polar solvents to produce optimal yields, but it is difficult to separate the solvent from the oil, and there are no precise measurements.
d) The extraction process using the press method has not been widely used in laboratory-scale research, but the press method is the method used by the oil industry

3.1.3 Cluster 3

a) The total oil yield test still uses the soxhletation method, which can only be carried out in the laboratory. Developing a portable test method that can be used anywhere is necessary.
b) The process of optimizing oil needs to pay attention to the main components of oil, such as crude and pure, currently, the optimization process still uses toxic materials
c) Oil analysis needs to be standardized in crude oil so that it becomes the basis for development and follow-up
d) Crude oil recommendations are currently unclear and put forward by researchers because they only convey research results
e) There have been no techno-economic studies conducted by researchers to produce crude oil

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3.2 Development of vegetable oil extraction methods

Literature was collected through searches using the publish or perish application with Scopus and Google Scholar sources and 300 literature articles discussing crude oil extraction and its applications. Furthermore, the selection of articles was carried out into 200 articles that specifically discussed the extraction method used. The 200 articles obtained were then analyzed using VOSviewer to see the relationship between the oil extraction method and several related topics in Figures 2,3 and 4. It can be seen that the research relationship regarding oil extraction is limited to searching journal articles from 2017-2023.

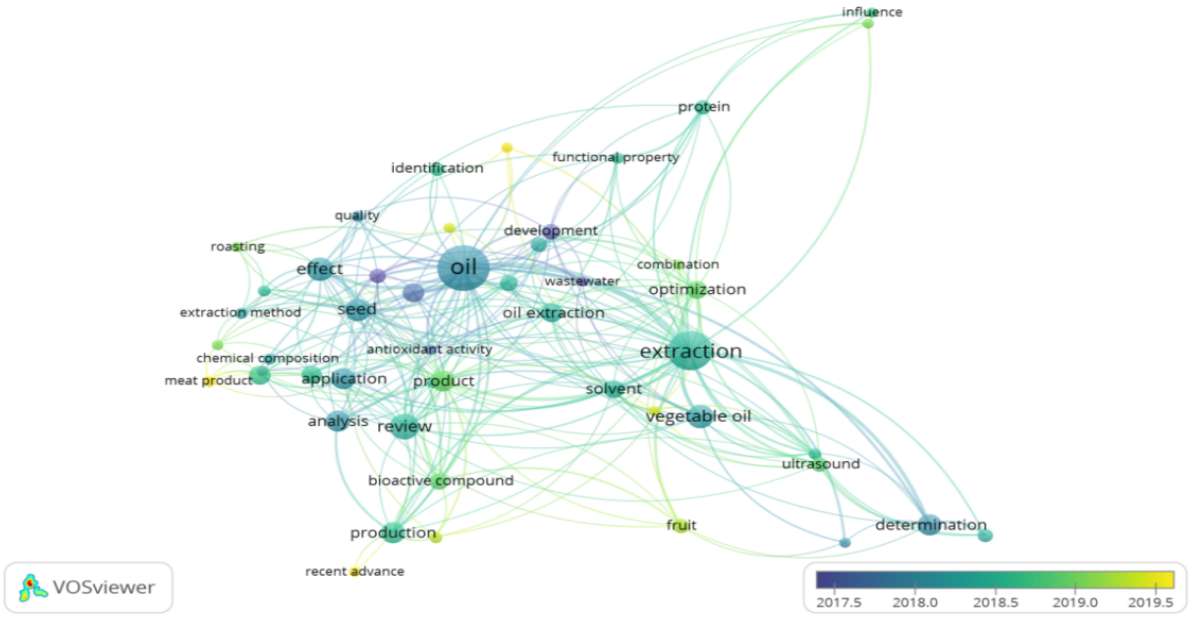

Figure 2. Relationship of Vegetable Oil Extraction Research

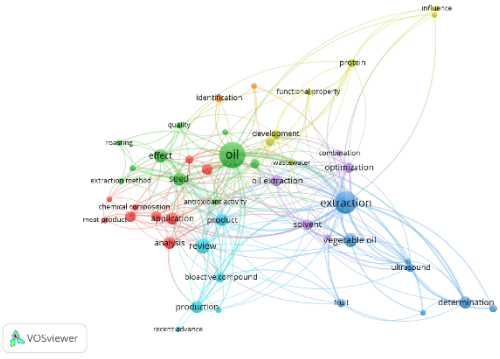

Figure 3. Network Visualization

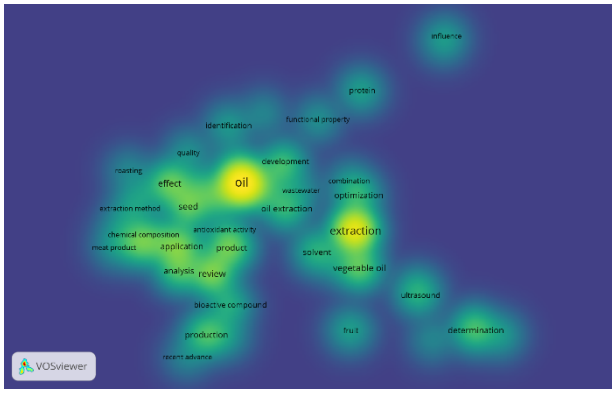

Figure 4. Density Visualization

Analysis using VOSviewer explains that several research relations of oil extraction produce 49 items, 7 clusters, and links of 264 related words. Then, it also explains the novelty of research or research that has not been widely developed, namely the yellow items and links. This analysis can answer the first research question of to what extent research on crude oil extraction is carried out.

3.3 Exploration of oil resources and extraction methods in Indonesia

Journal articles with the theme of oil extraction have been selected from 300 journals to 100 journals and then continued to 25 relevant journals to see the development of oil extraction methods that have been carried out in several studies in Indonesia. In table 1. Several researchers in Indonesia have investigated the sources of vegetable oil.

Table 1. Development of Crude Oil Extraction Methods in Indonesia

Numb	Author	Commodity	Extraction Method	Yield	Publication Years
1	[6]	Yellow Pumpkin Seeds	Soxhlet Extraction	56.40%	2021
2	[7]	Orok-Orok Seeds	Liquid Solid Extraction	19.943%	2019
3	[8]	Avocado Seeds	Soxhlet Extraction	4.6%	2019
4	[9]	Avocado Seeds	Soxhlet Extraction	32.8%	2019
5	[10]	Yellow Pumpkin Seeds	Soxhlet Extraction	37.98%	2018
6	[11]	Avocado Seeds	Soxhlet Extraction	2.8112 %	2020
7	[12]	Mango Seeds	extraction and distillation processes	58%	2017
8	[13]	Ketapang Seeds	Soxhlet Extraction	60.187%	2020
9	[14]	Coconut	Fermentation	20%	2021
10	[15]	Rubber Seeds	Soxhlet Extraction	14.12 %	2017
11	[16]	Rubber Seeds	Making Traditional Coconut Oil	8.15%	2021
12	[17]	Bintangur Seeds	Soxhlet Extraction	73.71%	2019
13	[18]	Nyamplung Seeds	Soxhlet Extraction	58.2%	2017
14	[19]	Mango Seeds	maceration	29.62%	2022
15	[20]	Avocado Seeds	Soxhlet Extraction	19.44	2019
16	[21]	Mango Seeds	Multilevel Extraction	24.91%	2017
17	[22]	Jatropha Seeds	seed press	57.7%	2020
18	[23]	Sunflower seeds	Soxhlet Extraction	32.93%	2019
19	[24]	Tea Seeds	Soxhlet Extraction	14%	2017
20	[25]	Palm Fruit	Ultrasonication	22.25%	2022
21	[26]	Basil Seeds	Soxhlet Extraction	5.1%	2020
22	[27]	Peanut Seeds	Soxhlet Extraction	58.29%	2021
23	[1]	a) Hazelnut Seeds b) Sesame Oil c) Soybean Oil d) Corn Seeds e) Sunflower Seeds	Soxhlet Extraction	a) 52.44% b) 34.23 % c) 48.68 % d) 36.97 % e) 69.28%	2018
24	[28]	Avocado Seeds	Soxhlet Extraction	66%	2018
25	[29]	kenaf seeds	Screw press	32.32%	2020

The results of a review of articles and publications on the topic of crude oil extraction in several vegetable oil sources show that the method that is often developed is the soxhlet extraction method also known as the soxhlet system. Various researchers have studied the physicochemical properties of seed oil extracted by using the Soxhlet method [30] [31]; [32] and cold-pressed method [33]; [34]. The extraction technique can determine the required oil quality. Consequently, an analysis of factors that influence oil usage in different food preparations, such as fatty acid content, oxidative stability, thermal profile, TAG profile, and alterations in chemical bonds in the TAG molecule, is required.

This extraction method uses solvents and a distillation process to extract oil materials. Before extracting the material, several steps need to be carried out, such as drying and size reduction, so that the extraction process achieves optimum results. Pumpkin (*Cucurbita moschata Duch.*) seeds of KH (Kashi Harit) cultivar were chosen for oil extraction by three different methods cold press extraction (CPE), soxhlet extraction (SE), and mechanical shaking extraction (MSE) method. SE method showed highest oil yield (38.03%) followed by CPE (33.25%) and MSE (26.36%) methods. Peroxide and acid values were found to be the lowest in the CPE pumpkin seed oil (PSO) while the oil stability index was the highest in this oil [5], cold pressing process aqueous enzymatic extraction on linseed oil quality. The research results show thatoil has a high γ-tocopherol and squalene content.[35], gardenia fruit oil produced by subcritical butane extraction (SBE) and cold-pressed extraction (CPE) dan This indicated that the SBE technology was an ideal alternative for the industry to produce gardenia oil with very good physiological activity [36].

The properties of pumpkin seed oil (PSO) were evaluated by the physical and chemical characteristics of different origins extracted using hot extraction, Soxhlet, and ultrasound-assisted methods. The extraction technique using hot extraction Antioxidant (98.71%) with Soxhlet has the highest antioxidant activity based on the β-carotene bleaching method (73.28%). demonstrated the potential antioxidant activity of PSO extracted using hot pressing with good physicochemical properties, making it suitable for industrial applications [37]

3.4 Optimization, Analysis, and Sustainability of Crude Oil Extraction Results

The results of the selection of 25 journals that carried out the process of extracting crude oil obtained 4 journals that carried out optimization and follow-up on the use of crude oil produced from vegetable materials, and the first was an extraction of oil sourced from pumpkin seeds using the soxhlet method using n-hexane solvent to carry out the degumming process and neutralization so as to produce an oil yield of 76.27%. A follow-up study was conducted on rubber seeds to process the oil into raw material for making transparent soap. Table 2. It can be seen that 4 studies have been developed to optimize and follow up on the use of crude oil produced from the extraction process.

Table 2. Optimization and follow-up of extracted crude oil

Commodity	Research	Solvent	Analysis	Continuous step
Yellow Pumpkin Seeds	[10]	n-hexane	Density, Moisture Content, Acid Number, Peroxide Number, Saponification Number, Oil Refining	optimum results after purification using 0.15% H3PO4 of 76.27%
Rubber Seeds	[15]	n-hexane	Components of Rubber Seed Oil Result of GC-MS Analysis	Used for making Transparent Soap
Nyamplung Seeds	[18]	mixture of hexane and ethanol	acid number, iodine number, viscosity, density	extraction also obtains resin

Commodity	Research	Solvent	Analysis	Continuous step
Basil Seeds	[26]	n-hexane	density, water content, acid number, peroxide, saponification, fatty acid profile	high squalene content

Follow-up results of crude oil extraction need to be done to improve the function of the oil and provide added value to the product; if necessary, a purification process is carried out to increase the yield, and it can be used as pure oil. Superworm (Zophobas morio) has fatty acids and high productivity, so it has the potential to be used as a raw material for cooking oil. Neutralization with NaOH is a solution to improve the quality of superworm cooking oil [38]. In optimizing the nutritional value of extracted oil, the possibility of enriching refined sunflower oil with omega-3 fatty acids by adding cold-pressed linseed oil to obtain a new vegetable oil with high nutritional value has been investigated.[39]. Furthermore, for follow-up on the processing of new oil and advanced crude oil which aims to be used as edible oil, it is necessary, especially for food products, to carry out a toxicity analysis so that it does not have an impact and risk to consumers and its use is more targeted [40].

4. Conclusion

In this study, a systematic literature review method was used with the research topic regarding evaluating the development of oil extraction methods for the resulting crude oil. From the 300 articles selected, the next 100 articles were selected to become 25 relevant articles, so the research data was obtained to obtain the results. The optimum is the soxhlet extraction method, then from 25 articles, selected 4 articles that performed optimization and follow-up on the oil results obtained, namely by purifying the oil and applying it to the product. This extraction method has not been developed on an industrial scale, only on a research or laboratory scale. The most widely used in the process of extracting oil on an industrial scale is the screw method, or known as the screw press.

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