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*Review Article*

# Review article: Flavonoid Extraction Method of Parsley Leaf Extract (*Petroselinum crispum*)

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**Abstract:** Flavonoids are bioactive polyphenolic compounds known for their antioxidant, anti-inflammatory, and antimicrobial properties. Although widely distributed in plants, parsley (*Petroselinum crispum*) is highlighted for its high flavonoid content, which is recognized as the dominant class of secondary metabolites compared to other constituents such as essential oils and pigments, making it a strong candidate for pharmaceutical applications. This review aimed to evaluate and compare various extraction methods used to isolate flavonoids from parsley leaves. A systematic literature search was conducted through Google Scholar, Scopus, and PubMed for articles published between 2014 and 2024 using keywords "flavonoid," "parsley leaves," and "extraction method." Inclusion criteria comprised full-text original articles in English or Indonesian reporting extraction methods and total flavonoid content; reviews and incomplete studies were excluded. Among the methods reviewed, Ultrasonic-Assisted Extraction (UAE) proved most effective. When normalized to 1 g/minute, UAE yielded 0.312 mg/g of total flavonoids, demonstrating higher efficiency in terms of extraction yield and time. UAE utilizes acoustic cavitation to enhance solvent penetration and mass transfer, improving yield while preserving compound integrity. Ethanol was identified as the optimal solvent due to its polarity and compatibility with flavonoid structures. In conclusion, UAE with ethanol presents a promising strategy for efficient flavonoid extraction from parsley in pharmaceutical and nutraceutical applications.

**Keywords:** extraction method; flavonoid; parsley leaves

## 1. INTRODUCTION

Flavonoids are a diverse group of polyphenolic compounds known for their potent antioxidant, anti-inflammatory, and antimicrobial properties [1]. These bioactive molecules are widely present in various medicinal plants and have gained increasing attention in recent years as potential natural alternatives to synthetic drugs. However, their application is often hindered by chemical instability when exposed to heat, light, or extreme pH, which can lead to degradation during processing and reduce their therapeutic efficacy [2]. Therefore, selecting an appropriate extraction method is essential to ensure the optimal yield and preservation of flavonoid compounds in plant-based formulations.

One plant that has emerged as a promising source of flavonoids is parsley (*Petroselinum crispum*) [3]. Parsley has demonstrated antibacterial activity, including against *Escherichia coli*, a major causative agent of diarrheal diseases, particularly in developing countries [4]. In Indonesia, diarrhea

remains a significant public health issue, with a prevalence of 6.8% in 2018, making it one of the leading causes of morbidity, especially in children under five years old [5]. The search for effective, natural antibacterial agents is therefore critical. Parsley has long been used traditionally across various cultures as a medicinal herb, passed down from generation to generation, particularly for digestive disorders, urinary tract infections, and as a general health tonic [6]. These ethnopharmacological uses support its potential as a natural antibacterial agent, making it relevant for further scientific investigation.

Parsley is herbaceous plant that contains various bioactive compounds with important pharmacological properties [7]. Among these, flavonoids such as apigenin, luteolin, and kaempferol represent the dominant class of secondary metabolites, with total flavonoid content reported to reach approximately 1,435 mg QE per 100 g dry leaves, a level significantly higher than that of pigments or essential oils [8]. These flavonoids are well known for their strong antioxidant and antibacterial activity against pathogenic bacteria such as *Pseudomonas aeruginosa*. It also contains coumarins, terpenoids, and phenolic acids like caffeic acid and ferulic acid, that contribute to its anti-inflammatory and antimicrobial effects [9]. In addition, parsley is rich in essential oils, including myristicin and apiol, which have been shown to possess antispasmodic and antibacterial effects [10]. Other notable components include carotenoids, chlorophyll, and important vitamins such as vitamin C and vitamin K, that further support its antioxidant and health-promoting properties [11]. These diverse compounds make parsley a highly valuable medicinal plant with potential for various therapeutic applications, including as a natural antibacterial agent whose mechanism involves damaging the bacterial cell membrane and inhibiting microbial growth [12]. With this wide range of active constituents, parsley presents a promising candidate for further exploration in therapeutic development, particularly through the optimization of extraction techniques to isolate its key bioactive compounds.

The primary flavonoids in parsley not only contribute to its broad pharmacological effects but are also chemically sensitive. Due to their sensitivity to heat, light, and pH fluctuations, flavonoids may degrade during processing, resulting in reduced extract yield and efficacy [13]. Therefore, selecting an appropriate extraction method is essential to maximize the yield, preserve compound stability, and enhance biological efficacy of the resulting extracts.

Various extraction techniques have been developed to extract active compounds from plants, including conventional methods such as Maceration and Soxhlet, as well as modern methods such as Microwave-Assisted Extraction (MAE) and Ultrasound-Assisted Extraction (UAE) [14]. Choosing the right extraction method can increase the yield of active compounds, as well as streamline the use of solvents and shorten the extraction time.

According to research conducted by Moni *et al*. (2021), it is said that parsley leaf extract has a significant antibacterial effect against Gram-positive and Gram-negative bacteria, with effectiveness depending on the extraction method, type of solvent used, and extract concentration. Therefore, optimizing the extraction method is an important step to obtain maximum antibacterial content from parsley leaves [15].

Based on this background, the researcher aims to collect the latest research that has been done regarding flavonoid extraction methods in parsley leaves (*Petroselinum crispum*) in order to obtain more optimum extract results. These results are expected to contribute to the development of more effective extraction methods and solvent selection strategies in the extraction process of flavonoids

in parsley leaves (*Petroselinum crispum*) that are more applicable to the pharmaceutical industry, especially in the development of natural antibacterial agents.

## 2. MATERIALS AND METHODS

The methods used in this study were collected from various literature sources. This literature review was carried out using a systematic and targeted approach to collect relevant studies concerning the extraction and identification of flavonoid compounds from parsley leaves (*Petroselinum crispum*). The sources of data were obtained from multiple digital scientific databases, namely Google Scholar, PubMed, Scopus, and Google Search, covering studies published between 2014 and 2024. The search process utilized specific combinations of keywords, including "flavonoid extraction," "parsley leaves," "*Petroselinum crispum*," and "total flavonoid content," to locate the most relevant and recent publications.

The selection of studies followed a set of eligibility criteria. The inclusion criteria applied in this review encompassed original research articles written in either English or Indonesian, available in full-text format, and containing clear and complete information regarding the methods of flavonoid extraction or the quantification of total flavonoid content from parsley leaves. In contrast, the exclusion criteria consisted of review articles, conference abstracts, editorials, opinion papers, and any publications that did not focus on flavonoid extraction or lacked adequate methodological details.

Each article retrieved was screened first by reviewing its title and abstract. Those deemed potentially relevant were then read in full to determine their inclusion in the review. The final pool of selected articles was analyzed descriptively, focusing on the extraction techniques used, solvent types, and the outcomes related to flavonoid yield or biological activity. Since the number of Scopus-indexed articles specifically addressing this topic was limited, additional credible literature from sources indexed in Google Scholar and SINTA (Science and Technology Index) was included to provide a more comprehensive perspective, particularly reflecting research from Asian contexts where parsley-based traditional medicine is commonly studied.

## 3. RESULTS AND DISCUSSION

Based on the search results from various literature sources, a total of 37 scientific articles were initially identified using keywords such as "flavonoid extraction," "parsley leaves," "*Petroselinum crispum*," and "total flavonoid content." After applying the predefined inclusion and exclusion criteria, 11 articles were selected for in depth review. These selected articles fulfilled all eligibility requirements, including providing complete data on flavonoid extraction methods and quantification from parsley leaves (*Petroselinum crispum*).

The reviewed articles employed various extraction techniques and solvents to isolate flavonoid compounds, including Maceration, Soxhlet, Ultrasound-Assisted Extraction (UAE), and Microwave-Assisted Extraction (MAE). As illustrated in figure 1, out of the 11 reviewed articles, 3 (27%) utilized maceration, 3 (27%) employed Soxhlet extraction, 4 (37%) applied UAE, and 1 (9%) used the MAE technique.

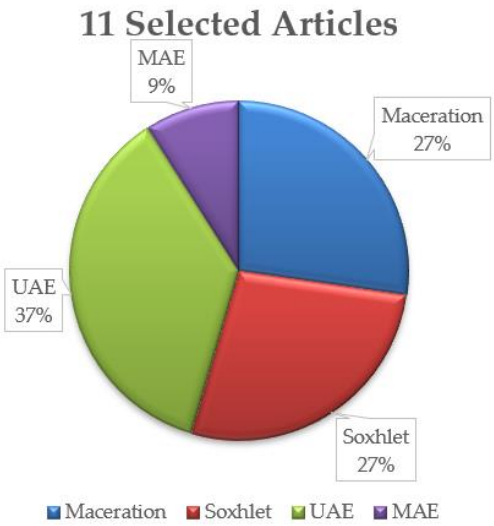


**Figure 1.** Classification of 11 Selected Articles

*3.1. Maceration*

The maceration method is a traditional extraction method that utilizes the process of immersing simplisia powder in a solvent or liquid extractor without heating [16]. The working principle of maceration is through the process of immersing the sample with a solvent for a predetermined duration. The soaking process will cause the breakdown of cell walls due to pressure differences, causing secondary metabolites to dissolve [17]. The flow of solvent into the cell will cause the protoplasm to swell and the target compound to dissolve according to its solubility [18].

**Table 1.** Results of the Maceration Method Review

| Preparation | Instrument | Result | Reference |
|---|---|---|---|
| 4 g parsley leaf powder with 100 mL ethanol 80% for 2 hours | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 61.18 mg/g | [19] |
| 2 g parsley leaf powder with 100 mL water for 48 hours | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 0.0021 mg/g | [20] |
| 2 g parsley leaf powder with 50 mL ethanol 80% - water mixture (50:50 v/v) for 2 hours | Spectrophotometer UV-Vis with $\lambda$= 330.0 nm | Total flavonoids: 8.82 mg/g | [21] |

Based on the data in Table 1, difference in treatment or solvent variation has a major influence on the yield of the extract. Solvent selection based on its polarity is very important, where solvents with appropriate polarity will attract more compounds. In accordance with the principle of "like dissolves like", where polar compounds will dissolve in solvents that are polar and vice versa. Flavonoids are polar compounds that will dissolve more easily in polar solvents [22]. The highest total flavonoid yield, reaching 61.18 mg/g, was obtained using 80% ethanol with a relatively short maceration time of 2 hours. This result may be attributed to several supporting factors, such as the larger sample mass (4 g), sufficient solvent volume (100 mL), and the use of ethanol, which possesses optimal polarity for extracting flavonoid compounds.

Compared to another solvent such as water, ethanol has a greater ability to attract flavonoids because it is more polar and suitable for dissolving amphiphilic compounds, such as flavonoids that contain both lipophilic aromatic rings and polar hydroxyl groups [23]. On the other hand, the use of water as a single solvent yielded the lowest flavonoid content, only 0.0021 mg/g, indicating its limited ability to extract less polar flavonoid components. Meanwhile, the ethanol water mixtures in a 50:50 ratio produced moderate flavonoid yields (8.82 mg/g), suggesting that dilution of ethanol may reduce extraction effectiveness due to changes in solvent polarity and decreased compound solubility [24].

*3.2. Soxhlet*

The soxhlet method is one of the conventional or traditional extraction techniques. This method is known for its ability to produce larger amounts of extract using less solvent and extraction duration [25]. The soxhlet method allows the sample to be extracted maximally because the extraction process is carried out repeatedly [26]. The working principle starts with placing the sample in a cellulose thimble positioned over a boiling solvent. When the solvent evaporates and condenses, droplets fall onto the sample, dissolving the active compounds within. The solution then flows back into the boiling solvent below, creating an extraction cycle that continues to repeat for several hours [27].

**Table 2.** Results of the Soxhlet Method Review

| Preparation | Instrument | Result | Reference |
|---|---|---|---|
| 20 g parsley leaf powder with 250 mL ethanol 70% for 6 hours | Spectrophotometer UV-Vis with $\lambda$= 280.0 nm | Total flavonoids: 18.51 mg/g | [28] |
| 20 g parsley leaf powder with 250 mL ethanol 70% for 24 hours | Spectrophotometer UV-Vis with $\lambda$= 280.0 nm | Total flavonoids: 20.4 mg/g | [29] |
| 200 g parsley leaf powder with 440 mL acetone - water mixture (9:13 v/v) for 10 hours | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 2.80 mg/g | [30] |

Based on the data in Table 2, the method of soxhlet with variations in extraction time gives different results on flavonoid content. The ethanol solvent treatment for 6 hours produced total flavonoids of 18.51 mg/g and treatment with ethanol for 24 hours produced total flavonoids of 20.4 mg/g. Treatment with a longer duration gives a greater total flavonoids result. Longer extraction duration can provide more opportunities for solvents to penetrate into plant tissues, increase cell wall permeability, and diffusion of flavonoid compounds into the solvent [31].

In contrast, the use of an acetone water mixture (9:13 v/v) with a larger solvent volume of 440 mL resulted in a much lower flavonoid yield of 2.80 mg/g. Despite the increased volume and relatively long extraction time (10 hours), the solvent's lower polarity limited its ability to dissolve flavonoid compounds effectively [32]. Acetone, although miscible with water, is less polar than ethanol and less compatible with the amphiphilic nature of flavonoids, especially glycosylated types that are more polar. Additionally, excessive solvent volume does not always correlate with higher yield if the solvent is not chemically suited to the target compound [33].

*3.3. Ultrasonic Assisted Extraction (UAE)*

The Ultrasonic Assisted Extraction (UAE) method is a modern extraction technique. This method utilizes ultrasonic waves to enhance the extraction process of target compounds [34]. The

basic principle of the UAE extraction method lies in the cavitational effects that occur on plant cell walls and membranes. The process involves high amplitudes that enhance the penetration of the solvent into the cell membrane, thereby accelerating the mass transfer rate. This, the extraction process produces optimal yields and residual solvent levels that comply with standards [35].

**Table 3.** Results of the Ultrasonic Assisted Extraction Method Review

| Preparation | Instrument | Result | Reference |
|---|---|---|---|
| 4 g parsley leaf powder with 100 mL ethanol 80% at 40°C for 30 minutes, 60 kHz frequency and 400 W power. | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 37.48 mg/g | [19] |
| 0.4 g parsley leaf powder with 10 mL ethanol 70% at 80°C for 8 minutes, 20 kHz frequency and 500 W power. | Spectrophotometer UV-Vis with $\lambda$= 280.0 nm | Total flavonoids: 9.48 mg/g | [28] |
| 0.6 g parsley leaf powder with 6 mL ethanol 80% mixture at 70°C for 25 minutes, 40 kHz frequency and 75 W power. | Spectrophotometer UV-Vis with $\lambda$= 280.0 nm | Total flavonoids: 0.0248 mg/g | [36] |
| 0.6 g parsley leaf powder 6 mL with ethanol 80% mixture at 25°C for 25 minutes, 40 kHz frequency and 75 W power. | | Total flavonoids: 0.0153 mg/g | |
| 0.6 g parsley leaf powder with 6 mL ethanol 80% mixture at 70°C for 25 minutes, 20 kHz frequency and 75 W power. | | Total flavonoids: 0.0210 mg/g | |
| 1 g parsley leaf powder with 10 mL ethanol 80% at 40°C for 30 minutes, 40 kHz frequency and 90 W power. | Spectrophotometer UV-Vis with $\lambda$= 337.0 nm | Total flavonoids: 4.7 mg/g | [37] |

The temperature used during the extraction process can affect the extraction results. Based on the data obtained in Table 3, the temperature treatment of 75°C on a sample of 0.6 g with a frequency of 40 kHz produced total flavonoids of 0.0248 mg/g, while the lower temperature treatment of 25°C under the same conditions yielded only 0.0153 mg/g. This demonstrates that temperature affects both solubility and compound stability. Flavonoids are compounds that tend to be unstable at high temperatures [38]. Extraction temperatures that are too high can cause flavonoid degradation through the process of breaking molecular chains and oxidation reactions [39]. This process triggers the oxidation of hydroxyl groups in the flavonoid structure, which eventually forms volatile compounds. Therefore, optimizing the appropriate temperature for the extraction process is very important to maintain the stability and effectiveness of the flavonoid compounds produced [40].

In another case, a treatment at 80 °C using 0.4 g sample and 20 kHz frequency produced a considerably higher yield of 9.48 mg/g. Meanwhile, an extraction at 40 °C yielded 4.7 mg/g. This indicates that the effect of temperature is also influenced by other interacting parameters such as frequency, solvent composition, and sample to solvent ratio. The frequency of ultrasonic waves used will affect the cavitation intensity, the frequency treatment of 40 kHz at 70°C with 0.6 g sample gave the best result of 0.0248 mg/g, while the frequency of 20 kHz at 70°C with 0.6 g sample only produced

0.0210 mg/g flavonoids. The frequency of ultrasonic waves is directly proportional to cavitation intensity, which disrupts plant cell walls, enlarges pores, and enhances the release of bioactive compounds like flavonoids. This effect improves mass transfer, accelerates diffusion into the solvent, and increases extraction yield [41]. In addition, the ratio of simplisia to solvent is another critical factor influencing extraction yield. A higher solvent volume promotes better solubility and prevents saturation, allowing greater migration of flavonoids into the solvent. However, if the solvent volume is excessively large, it may reduce the concentration gradient and thereby lower the driving force for diffusion [42].

*3.4. Microwave Assisted Extraction (MAE)*

The Microwave-Assisted Extraction (MAE) method is a modern extraction technique that uses microwave energy to accelerate the extraction process of soluble materials in plants selectively [43]. MAE has the advantage of utilizing microwave radiation, where the solvent will heat up faster, making electromagnetic waves able to penetrate the simplisia cell wall and evenly excite water and fat molecules, so as to increase the effectiveness of extraction [44].

**Table 4.** Results of the Microwave Assisted Extraction Method Review

| Preparation | Instrument | Result | Reference |
|---|---|---|---|
| 0.6 g parsley leaf powder with ethanol 80% for 12 minutes at 60°C with 800 W power. | Spectrophotometer UV-Vis with $\lambda$= 510.0 nm | Total flavonoids: 6.977 mg/g | [45] |
| 0.6 g parsley leaf powder with ethanol 80% for 6 minutes at 60°C with 800 W power. | | Total flavonoids: 6.322 mg/g | |

Based on the data from Table 4, the treatment of 60°C for 6 minutes with 800 W power and 60°C for 12 minutes with 800 E power showed differences in total flavonoid yield, namely 6.977 mg/g and 6.322 mg/g. It can be seen that longer extraction conditions do not always result in higher flavonoid content. This can occur due to thermal degradation, where the heat generated by microwaves can cause damage to the flavonoid structure, especially if the extraction lasts too long. The sensitivity of flavonoids as bioactive compounds to heat can cause oxidation, hydrolysis, or changes in chemical structure, which reduces their effectiveness [46].

*3.5. Most Effective Treatment*

Each extraction method reviewed in this study was selected based on the most optimized treatment conditions reported in the respective articles. These conditions, such as extraction time, solvent volume, temperature, and equipment-specific parameters were considered the most suitable within the context of each method. Their effectiveness was reflected in the relatively high total flavonoid content they produced under those conditions. For example, on table 3, UAE showed the best performance using a combination of optimized variables that supported higher mass transfer efficiency. The selection of these particular data points aimed to represent the peak potential of each technique, providing a fair basis for method comparison.

**Table 5.** Review Results of the Most Effective Treatment of Each Parsley Leaf Extraction Method

| Method | Preparation | Instrument | Result | | Reference |
|---|---|---|---|---|---|
| | | | According to Source | 1 g/ 1 minute | |
| Maceration | 4 g parsley leaf powder with 100 mL ethanol 80% for 2 hours | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 61.18 mg/g | Total flavonoids: 0.127 mg/g | [19] |
| Soxhlet | 20 g parsley leaf powder with 250 mL ethanol 70% for 24 hours | Spectrophotometer UV-Vis with $\lambda$= 280.0 nm | Total flavonoids: 20.4 mg/g | Total flavonoids: 0.0007 mg/g | [29] |
| Ultrasonic Assisted Extraction (UAE) | 4 g parsley leaf powder with 100 mL ethanol 80% at 40°C for 30 minutes, 60 kHz frequency and 400 W power. | Spectrophotometer UV-Vis with $\lambda$= 415.0 nm | Total flavonoids: 37.48 mg/g | Total flavonoids: 0.312 mg/g | [19] |
| Microwave-Assisted Extraction (MAE) | 0.6 g parsley leaf powder with ethanol 80% for 12 minutes at 60°C with 800 W power. | Spectrophotometer UV-Vis with $\lambda$= 510.0 nm | Total flavonoids: 6.977 mg/g | Total flavonoids: 0.268 mg/g | [45] |

Based on the data obtained from Table 5. The most effective method used to extract flavonoid compounds from parsley (*Petroselinum crispum*) leaves is the Ultrasonic-Assisted Extraction (UAE) method. The UAE method is more effective in utilizing extraction materials and achieving higher flavonoid yields than conventional methods, such as maceration, soxhlet, or Microwave-Assisted Extraction (UAE). UAE utilizes ultrasonic energy to increase solvent penetration into the cell membrane, thereby accelerating the mass transfer rate of the target compounds, namely flavonoids [36].

The ultrasonic wave energy in UAE is able to create pressure that causes the breakdown of cell walls more effectively and makes it easier for bioactive compounds such as flavonoids to dissolve into the solvent. This makes the UAE method not only faster but also reduces solvent usage compared to other methods. The short extraction process can also help minimize the risk of degradation of flavonoid compounds, which are known to be susceptible to heat and oxidation [40].

Compared to maceration and soxhlet methods that require hours or days of extraction time, UAE only takes minutes to provide more optimal results [47]. Based on the number of samples of maceration and UAE methods in Table 5, the UAE method can produce more total flavonoids than the maceration method if the duration is equalized, namely UAE can produce 37.48 mg/g of total flavonoids. This is because UAE utilizes ultrasonic which can increase plant cell permeability and have an impact on increasing the levels of bioactive compounds [48].

When compared with the MAE method in Table 5. The MAE method with a duration of 12 minutes produces total flavonoids of 6.977 mg/g, less than the UAE method which produces total flavonoids of 37.48 mg/g with a duration of 30 minutes. If the amount of solvent and duration are

equalized, the MAE method will produce a total flavonoid 0.268 mg/g with 1 g sample and 1 minute duration, which is lower than the UAE method that can produce a total flavonoid content of 0.312 mg/g. This is due to the different extraction mechanisms used. UAE utilizes ultrasonic waves to create cavitation that produces high pressure waves, so that cell walls break more easily and the release of active compounds is maximized [41]. In addition, UAE works at a lower temperature than MAE which can accelerate extraction by direct heating through microwave radiation, excessive heat can cause degradation of flavonoid compounds, so the total amount of flavonoids obtained is less than UAE [49].

The effectiveness of the UAE method is also influenced by several interacting parameters, including ethanol concentration, extraction temperature, ultrasonic frequency, and applied power [50]. The use of 80% ethanol provides an optimal polarity balance, enabling better solubility of both hydrophilic and lipophilic flavonoid structures [51]. A moderate temperature of 40 °C helps prevent thermal degradation of sensitive flavonoid compounds while maintaining sufficient energy for effective mass transfer. Furthermore, the application of a 60 kHz ultrasonic frequency combined with 400 W power enhances cavitation intensity, increases solvent penetration, disrupts cell walls, and accelerates the release of intracellular flavonoids [52]. These synergistic factors contribute to the high yield of flavonoids observed under UAE conditions and emphasize the importance of optimizing each parameter in the extraction process.

In addition, the use of the type of solvent can also greatly affect the extraction results. Based on the data above, ethanol is the most effective solvent for extracting flavonoids from parsley leaves. This is due to the characteristics of ethanol which is polar, has a lipophilic aromatic ring structure, and hydroxyl (-OH) groups that are able to form hydrogen bonds with flavonoid compounds [53]. In the most optimal treatment (UAE), a simplisia-to-solvent ratio of 1:25 (4 g parsley leaf powder with 100 mL of 80% ethanol) was used, which effectively supported the dissolution and migration of flavonoid compounds. This balanced ratio ensures sufficient solvent availability for solubilizing target compounds without excessively diluting the extract, contributing to the high extraction yield observed. These characteristics make ethanol have a good ability to dissolve phenolic compounds, including flavonoids [24].

This review acknowledges several limitations. Primarily, the method comparisons are drawn from secondary sources, each potentially utilizing varied experimental setups, such as differences in sample origin, particle size, storage conditions, and analytical techniques a factor that may influence the reliability of direct comparisons. Furthermore, some articles lacked complete reporting on key variables like solvent volume, extraction temperature, and the ratio between plant material and solvent, thereby hindering a fully standardized evaluation. Therefore, future studies with controlled experimental designs are recommended to validate the most effective extraction method, solvent type, and ratio for isolating flavonoids from parsley leaves.

## 4. CONCLUSION

Ultrasound-assisted extraction (UAE) emerges as a highly effective technique for isolating flavonoid compounds from *Petroselinum crispum* (parsley) due to its efficiency in both time and solvent utilization. Among the evaluated methods, UAE applied to 4 g of parsley powder using 100 mL of 80% ethanol (1:25 ratio) resulted in the highest total flavonoid yield of 37.48 mg/g within 30 minutes, which corresponds to 0.312 mg/g per gram per minute. This extraction ratio effectively balanced solvent availability and concentration gradient, thus optimizing diffusion and preventing

over-dilution. Ethanol was identified as the most suitable solvent owing to its polar nature and strong interaction with flavonoid molecules. Accordingly, the UAE method combined with ethanol under optimal conditions represents the most promising approach for maximizing flavonoid extraction, making it highly applicable in the development of pharmaceutical and functional products.

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**References**

[1] Mulyani, Y., Febiani, L., and Yuniarto, A. Review Artikel Tanaman Bandotan (*Ageratum conyzoides* Linn) Sebagai Antibakteri, Antioksidan dan Antiinflamasi. *Praeparandi: Jurnal Farmasi dan Sains*, 5(1), 1-19, 2021, doi: doi.org/10.58365/aj5qqa57.

[2] Ioannou, I., Chekir, L., and Ghoul, M. Effect of Heat Treatment and Light Exposure on The Antioxidant Activity of Flavonoids. *Processes*, 8(9), 1-17, 2020, doi: doi.org/10.3390/pr8091078.

[3] Dobričević, N., Šic Žlabur, J., Voća, S., Pliestić, S., Galić, A., Delić, A., and Fabek Uher, S. Bioactive Compounds Content and Nutritional Potential of Different Parsley Parts (*Petroselinum crispum* Mill.). *Journal of Central European Agriculture*, *20*(3), 900-910, 2019, doi: doi.org/10.5513/jcea01/20.3.2417.

[4] Mufti, N., Bahar, E., and Arisanti, D. Uji Daya Hambat Ekstrak Daun Sawo Terhadap Bakteri *Escherichia coli* Secara In Vitro. *Jurnal Kesehatan Andalas*, 6(2), 289-294, 2017, doi: 10.25077/jka.v6i2.693.

[5] Kemenkes RI. *Profil Kesehatan Indonesia Tahun 2018*.; Jakarta: Kementrian Kesehatan Republik Indonesia. Indonesia, 2018.

[6] Umboro, R. O., and Apriliany, F. Aktivitas Antifungi Ekstrak Etanol Daun Parsley (*Petroselinum Crispum*) Terhadap Pertumbuhan Jamur *Candida albicans* Secara In Vitro. *Jurnal Kesehatan Qamarul Huda*, 10(2), 224-231, 2022, doi: 10.37824/jkqh.v10i2.2022.411.

[7] de Menezes Epifanio, N. M., Cavalcanti, L. R. I., Dos Santos, K. F., Duarte, P. S. C., Kachlicki, P., Ożarowski, M., and de Almeida Chaves, D. S. Chemical Characterization and In Vivo Antioxidant Activity of Parsley (*Petroselinum crispum*) Aqueous Extract. *Food & function*, 11(6), 5346-5356, 2020, doi: doi.org/10.1039/d0fo00484g.

[8] Ahmed, W. E., Almutairi, A. A., Almujaydil, M. S., Algonaiman, R., Mousa, H. M., and Alhomaid, R. M. Nutraceutical potential of parsley (*Petroselinum crispum* Mill.): Comprehensive overview. *Italian Journal of Food Science/Rivista Italiana di Scienza degli Alimenti*, *37*(1), 194-209, 2025, doi: 10.15586/ijfs.v37i1.2806.

[9] Alobaidi, S. Renal Health Benefits and Therapeutic Effects of Parsley (*Petroselinum crispum*): A Review. *Frontiers in Medicine*, 11(1), 1-10, 2024, doi: doi.org/10.3389/fmed.2024.1494740.

[10] Derouich, M., Bouhlali, E., Hmidani, A., Bammou, M., Bourkhis, B., Sellam, K., and Alem, C. Assessment of Total Polyphenols, Flavonoids and Anti-Inflammatory Potential of Three Apiaceae Species Grown in The Southeast of Morocco, *Scientific African*, 9(1), 1-7, 2020, doi: doi.org/10.1016/j.sciaf.2020.e00507.

[11] Slighoua, M., Mahdi, I., Moussaid, F. Z., Kamaly, O. A., Amrati, F. E. Z., Conte, R., and Bousta, D. LC-MS/MS and GC/MS Profiling of *Petroselinum sativum* Hoffm. and Its Topical Application on Burn Wound Healing and Related Analgesic Potential in Rats. *Metabolites*, 13(2), 1-19, 2023, doi: doi.org/10.3390/metabo13020260.

[12] Mahdi, I., Imbimbo, P., Annaz, H., Bakrim, W. B., Sahri, N., Alaoui, A., and Sobeh, M. Profiling of *Petroselinum sativum* (mill.) Fuss Phytoconstituents and Assessment of Their Biocompatibility, Antioxidant, Anti-Aging, Wound Healing, and Antibacterial Activities. *Frontiers in Nutrition*, 11(1), 1-12, 2024, doi: doi.org/10.3389/fnut.2024.1338482.

[13] Liu, J., Mu, T., Sun, H., and Fauconnier, M. L. Effects of Processing and Storage Conditions on The Stability of Sweet Potato (*Ipomoea batatas* L.) Leaf Flavonoids. *International Journal of Food Science & Technology*, 55(5), 2251-2260, 2020, doi: https://doi.org/10.1111/ijfs.14478.

[14] dos Santos Franciscato, L. M. S.; Mendes, S. S.; Frederico, C.; Goncalves, J. E.; Faria, M. G. I.; Gazim, Z. C.; and Ruiz, S. P. Parsley (*Petroselinum crispum*): Chemical Composition and Antibacterial Activity of Essential

Oil from Organic Against Foodborne Pathogens. *Australian Journal of Crop Science*, 16(5), 605-611, 2022, doi: 10.21475/ajcs.22.16.05.p3585.

[15] Moni, S. S.; Jabeen, A.; Sanobar, S.; Alam, M. S.; and Elmobark, M. E. Bioactive Constituents and In Vitro Antibacterial Properties of Petroselinum crispum Leaves, A Common Food Herb in Saudi Arabia. *Indian Journal of Natural Products and Resources (IJNPR)[Formerly Natural Product Radiance (NPR)]*, 12(3), 445-450, 2021, doi: 10.56042/ijnpr.v12i3.43084.

[16] Dewatisari, W. F. Perbandingan Pelarut Kloroform dan Etanol Terhadap Rendemen Ekstrak Daun Lidah Mertua (*Sansevieria trifasciata*. Prain) Menggunakan Metode Maserasi. *Prosiding Seminar Nasional Biologi*, 6(1), 127-132, 2020, doi: 10.24252/psb.v6i1.15638.

[17] Handoyo, D. L. Y. Pengaruh Lama Waktu Maserasi (Perendaman) Terhadap Kekentalan Ekstrak Daun Sirih (*Piper betle*). *Jurnal Farmasi Tinctura*, 2(1), 34-41, 2020, doi: doi.org/10.35316/tinctura.v2i1.1546.

[18] Yulianingtyas, A.; and Kusmartono, B. Optimasi Volume Pelarut dan Waktu Maserasi Pengambilan Flavonoid Daun Belimbing Wuluh (*Averrhoa bilimbi* L.) *Jurnal Teknik Kimia*, 10(2), 61-67, 2016, doi: 10.33005/jurnal_tekkim.v10i2.539.

[19] Aydın, C.; and Eser, F. Impact of Ohmic Heating Extraction on The Bioactive Components of Parsley: Comparison with Conventional and Green Extraction Techniques. *Journal of Food Measurement and Characterization*, 18(9), 7575-7584, 2024, doi: 10.1007/s11694-024-02749-7.

[20] Shehan, A. S.; Imthikab, A.; and Senanayake, G. M. Phytochemical screening, antioxidant and antimicrobial activities of the leaves from Parsley (*Apiaceae*) family plants grown in Sri Lanka. *BMS The Journal of Applied Learning*, 2(2), 82-92, 2024.

[21] Janković, S.; Mitić, M.; Arsić, B.; and Stankov-Jovanović, V. The Kinetic and Thermodynamic Studies of Solid-Liquid Extraction of Apigenin-Glycosides from Parsley (*Petroselinum crispum*). *Separation Science and Technology*, 56(13), 2253-2265, 2021, doi: 10.1080/01496395.2020.1821219.

[22] Yani, N. K. L. P.; Nastiti, K.; and Noval, N. Pengaruh Perbedaan Jenis Pelarut Terhadap Kadar Flavonoid Total Ekstrak Daun Sirsak (*Annona muricata* L.): The Effect of Different Types of Solvents on Total Levels of Flavonoid Extract (*Annona muricata* L.). *Jurnal Surya Medika (JSM)*, 9(1), 34-44, 2023, doi: 10.33084/jsm.v9i1.5131.

[23] Hikmawanti, N. P. E., Wiyati, T., Muis, M. A., Nurfaizah, F. A., and Septiani, W. Total flavonoids content of polar extracts of Cayratia trifolia leaves. In *IOP Conference Series: Earth and Environmental Science*, 819(1), 1-4, 2021, doi: doi.org/10.1088/1755-1315/819/1/012056.

[24] Bowden, N. A., Sanders, J. P., and Bruins, M. E. Solubility of The Proteinogenic $\alpha$-Amino Acids in Water, Ethanol, and Ethanol–Water Mixtures. *Journal of Chemical & Engineering Data*, 63(3), 488-497, 2018, doi: https://doi.org/10.1021/acs.jced.7b00486.

[25] Aytac, E. Comparison of Extraction Methods of Virgin Coconut Oil: Cold Press, Soxhlet and Supercritical Fluid Extraction. *Separation Science and Technology*, *57*(3), 426-432, 2022, doi: doi.org/10.1080/01496395.2021.1902353.

[26] Yasacaxena, L. N.; Defi, M. N.; Kandari, V. P.; Weru, P. T. R.; Papilaya, F. E.; Oktafera, M.; and Setyaningsih, D. Extraction of Temulawak Rhizome (*Curcuma xanthorrhiza* Roxb.) and Activity as Antibacterial. *Jurnal Jamu Indonesia*, 8(1), 10-17, 2023, doi: 10.29244/jji.v8i1.265.

[27] Wahyuningsih, N. E.; Susanto, N.; and Arifan, F. Uji Perbandingan Kandungan Zat Gizi Pada Opak Mentah dan Pada Opak Matang Guna Meningkatkan Kualitas Pemasaran dan Produksi di Kelurahan Candirejo Kecamatan Tuntang. *Seminar Nasional Kolaborasi Pengabdian kepada Masyarakat*, 1(1), 415-418, 2018.

[28] Ebrahimi, P.; Bayram, I.; Lante, A.; and Decker, E. A. Acid-hydrolyzed Phenolic Extract of Parsley (*Petroselinum crispum* L.) Leaves Inhibits Lipid Oxidation in Soybean Oil-In-Water Emulsions. *Food Research International*, 187(1), 1-10, 2024, doi: 10.1016/j.foodres.2024.114452.

[29] Ibrahiem, A. A.; Mosa, A. A.; and Mohammed, L. Y. Estimation of Oxidant, Antioxidant and Metabolic Biomarkers in Sera of Diabetic Rats Administrated with Parsley Leaves Extract and Its Isolated Apigenin. *Clinical Nutrition Open Science*, 54(1), 113-126, 2024, doi: 10.1016/j.nutos.2024.02.003.

[30] Deng, Y., Wang, W., and Liu, D. Ultrasound-Assisted Accelerated Penetration Extraction of Polyphenols from Pomegranate Peels: Enhanced Mass Transfer by Calcium Ion Precipitation and Utilization of Fick's Law. *Food and Bioprocess Technology*, 17(4), 1017-1029, 2024, doi: https://doi.org/10.1007/s11947-023-03181-3.

[31] Siswarni, M. Z.; Putri, Y. I.; and Rinda, R. Ekstraksi Kuersetin dari Kulit Terong Belanda (*Solanum betaceum* Cav.) Menggunakan Pelarut Etanol dengan Metode Maserasi dan Sokletasi. *Jurnal Teknik Kimia USU*, 6(1), 36-42, 2017, doi: 10.32734/jtk.v6i1.1563.

[32] Wakeel, A., Jan, S. A., Ullah, I., Shinwari, Z. K., and Xu, M. Solvent Polarity Mediates Phytochemical Yield and Antioxidant Capacity of Isatis tinctoria. *PeerJ*, 7(1), 1-19, 2019, doi: doi.org/10.7717/peerj.7857.

[33] Lezoul, N. E. H., Belkadi, M., Habibi, F., and Guillén, F. Extraction Processes with Several Solvents on Total Bioactive Compounds in Different Organs of Three Medicinal Plants. *Molecules*, 25(20), 1-15, 2020, doi: doi.org/10.3390/molecules25204672.

[34] Sholihah, M. A.; Ahmad, U.; and Budiastra, I. W. Aplikasi Gelombang Ultrasonik untuk Meningkatkan Rendemen Ekstraksi dan Efektivitas Antioksida dari Kulit Manggis. *Jurnal keteknikan pertanian*, 5(2), 161-168, 2017, doi: 10.19028/jtep.05.2.%25p.

[35] Farahani, A., Rahbar-Kelishami, A., and Shayesteh, H. Microfluidic Solvent Extraction of Cd (II) in Parallel Flow Pattern: Optimization, Ion Exchange, and Mass Transfer Study. *Separation and Purification Technology*, 258(1), 1-20, 2021, doi: https://doi.org/10.1016/j.seppur.2020.118031.

[36] Aldino, R.; Widyasanti, A.; dan Rosalinda, S. Proses Pembuatan Ekstrak Bunga Mawar (*Rosa* sp) dengan Metode Ultrasonic Assisted Extraction (UAE). *SEMINAR NASIONAL LPPM UMMAT*, 2(1), 37-41, 2023.

[37] Michalaki, A.; Karantonis, H. C.; Kritikou, A. S.; Thomaidis, N. S.; and Dasenaki, M. E. Ultrasound-Assisted Extraction of Specific Phenolic Compounds from *Petroselinum crispum* Leaves Using Response Surface Methodology and HPLC-PDA and Q-TOF-MS/MS Identification. *Applied Sciences*, 13(2), 1-17, 2023, doi: 10.3390/app13020798.

[38] Poureini, F.; Najafpour, G. D.; Nikzad, M.; Najafzadehvarzi, H.; and Mohammadi, M. Loading of Apigenin Extracted from Parsley Leaves on Colloidal Core-Shell Nanocomposite for Bioavailability Enhancement. *Colloids and surfaces A: Physicochemical and engineering aspects*, 625(1), 1-11, 2021, doi: 10.1016/j.colsurfa.2021.126867.

[39] Lin, S., Simal-Gandara, J., Cao, H., and Xiao, J. The Stability and Degradation Products of Polyhydroxy Flavonols in Boiling Water. *Current research in food science*, 6(1), 1-13, 2023, doi: doi.org/10.1016/j.crfs.2023.100509.

[40] Ariani, N.; Musiam, S.; Niah, R.; and Febrianti, D. R. Pengaruh Metode Pengeringan Terhadap Kadar Flavonoid Ekstrak Etanolik Kulit Buah Alpukat (*Persea americana* Mill.) dengan Spektrofotometri UV-VIS. *Jurnal Pharmascience*, 9(1), 40-47, 2022, doi: 10.20527/jps.v9i1.10864.

[41] Chemat, F.; Rombaut, N.; Sicaire, A. G.; Meullemiestre, A.; Fabiano-Tixier, A. S.; and Abert-Vian, M. Ultrasound Assisted Extraction of Food and Natural Products. Mechanisms, Techniques, Combinations, Protocols and Applications. A review. *Ultrasonics sonochemistry*, 34(1), 540-560, 2017, doi: 10.1016/j.ultsonch.2016.06.035.

[42] Gao, Y., Xia, W., Shao, P., Wu, W., Chen, H., Fang, X., and Gao, H. Impact of Thermal Processing on Dietary Flavonoids. *Current Opinion in Food Science*, 48(1), 1-8, 2022, doi: https://doi.org/10.1016/j.cofs.2022.100915.

[43] Bagade, S. B., and Patil, M. Recent Advances in Microwave Assisted Extraction of Bioactive Compounds from Complex Herbal Samples: A Review. *Critical reviews in analytical chemistry*, 51(2), 138-149, 2019, doi: doi.org/10.1080/10408347.2019.1686966.

[44] Putri, N. M.; Wiraningtyas, A.; and Mutmainah, P. A. Perbandingan Metode Ekstraksi Senyawa Aktif Daun Kelor (*Moringa oleifera*): Metode Maserasi dan Microwave-Assisted Extraction (MAE). *Dalton: Jurnal Pendidikan Kimia dan Ilmu Kimia*, 4(2), 25-33, 2021, doi: 10.31602/dl.v4i2.5931.

[45] El-Hadidy, E. M.; and Mostafa, O. F. Effect of conventional and microwave drying techniques on flat and curly parsley quality cultivated in Egypt. *Egyptian Journal of Agricultural Research*, 97(2), 345-362, 2019, doi: 10.21608/ejar.2019.150677.

[46] Maghfira, H. S.; Isnaeni; dan Darmawati, A. Pengaruh Suhu dan Waktu Pemanasan Larutan Serbuk Ekstrak Rosela (*Hibiscus Sabdariffa* L.) Terhadap Hambatan Pertumbuhan *Staphylococcus aureus* ATCC 25923. *Berkala Ilmiah Kimia Farmasi*, 8(2), 55-61, 2021, doi: 10.2043/bikfar.v8i2.31761.

[47] Anita, A. K. Pengaruh Perbedaan Metode Ekstraksi Terhadap Kadar Polifenol Daun Teh Putih (*Camellia sinensis*). *Jurnal Teknologi Pangan dan Ilmu Pertanian (JIPANG)*, 6(2), 48-55, 2024, doi: 10.36526/jipang.v6i02.4964.

[48] Rinawati, R.; Pangesti, G. G.; dan Juliasih, N. L. G. R. Green Analytical Chemistry: Pemanfaatan Supercritical Fluid Extraction (SFE) dan Microwave-Assisted Extraction (MAE) Sebagai Metode Ekstraksi Senyawa Diterpena Pada Minyak Biji Kopi Shangrai. *Analit: Analytical and Environmental Chemistry*, 5(1), 24-33, 2020, doi: 10.23960/aec.v5i1.2020.p24-33.

[49] Fauziyah, R.; Widyasanti, A.; and Rosalinda, S.; Perbedaan Metode Ekstraksi terhadap Kadar Sisa Pelarut dan Rendemen Total Ekstrak Bunga Telang (*Clitoria ternatea* L.). *Kimia Padjadjaran*, 1,(1), 18-25, 2022.

[50] Giri, S., Dash, K. K., Raj, G. B., Kovács, B., and Mukarram, S. A. Ultrasound Assisted Phytochemical Extraction of Persimmon Fruit Peel: Integrating ANN Modeling and Genetic Algorithm Optimization. *Ultrasonics Sonochemistry*, 102(1), 1-12, 2024, doi: doi.org/10.1016/j.ultsonch.2024.106759.

[51] Sarfarazi, M., Rajabzadeh, Q., Tavakoli, R., Ibrahim, S. A., and Jafari, S. M. Ultrasound-Assisted Extraction of Saffron Bioactive Compounds; Separation of Crocins, Picrocrocin, and Safranal Optimized by Artificial Bee Colony. *Ultrasonics Sonochemistry*, 86(1), 1-11, 2022, doi: doi.org/10.1016/j.ultsonch.2022.105971.

[52] Poureini, F., Mohammadi, M., Najafpour, G. D., and Nikzad, M. Comparative Study on The Extraction of Apigenin from Parsley Leaves (*Petroselinum crispum* L.) by Ultrasonic and Microwave Methods. *Chemical Papers*, *74*(11), 3857-3871, 2020, doi: doi.org/10.1007/s11696-020-01208-z.

[53] Zhao, T., Zheng, F., Liu, Y., Khan, A., Wang, Z., and Cheng, G. A Comparative Analysis of Chemical Constituents and Antioxidant Effects of *Dendrobium fimbriatum* Hook Fractions with Different Polarities. *International Journal of Molecular Sciences*, *24*(16), 1-20, 2023, doi: doi.org/10.3390/ijms241612646.