

Achmad Wildan

Green Synthesis of Ethyl Cinnamate through Ultrasonication Method And Its Evaluation as Antioxidant Activity

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Research Article

Green Synthesis of Ethyl Cinnamate through Ultrasonication Method And Its Evaluation as Antioxidant Activity

Erlita Verdia Mutiara¹, Achmad Wildan^{2*}, Athika Darumas Putri³, Erwin Indriyanti⁴

^{1,3,4} Department of Pharmacy, Sekolah Tinggi Ilmu Farmasi Yayasan Pharmasi Semarang, Indonesia

² Department of Pharmaceutical and Food Analysis, Sekolah Tinggi Ilmu Farmasi Yayasan Pharmasi Semarang, Indonesia

*Corresponding Author: achmadwildan58@gmail.com

Abstract. Cinnamic acid and its derivatives play an essential role in the production of various important compounds and serve as precursors for creating cinnamic esters. These compounds exhibit antioxidant activity. Among the derivatives of cinnamic acid is ethyl cinnamate. Ethyl cinnamate is produced through an esterification reaction between cinnamic acid and ethanol, utilizing a natural zeolite hierarchical-mesoporous system as a catalyst. The ultrasonication method is a technique developed for this synthesis process, as it is straightforward, efficient, yields high percentages, requires a short time, and is environmentally friendly. Following the synthesis results, the identification of the compound was conducted using melting point analysis, FTIR spectrophotometry, and GCMS. The analysis data from FTIR and GCMS indicate that the synthesized compound is ethyl cinnamate. The highest percent yield achieved was 36,36%, obtained after 2 h of sonication. The antioxidant activity, represented by the EC₅₀ value of the synthesized ethyl cinnamate compound, was found to be 95,74, categorizing it in the strong range.

Keywords: Antioxidant; EC₅₀; Ethyl Cinnamate; Ultrasonication; Zeolite.

1. Introduction

Cinnamic acid can be found in nearly all green plants, even in low concentrations [1]. It serves as a crucial link between the shikimate and phenylpropanoid pathways. Shikimic acid acts as a precursor for various alkaloids, aromatic amino acids, and indole derivatives. It exists in both free and ester forms (such as ethyl, cinnamon, and benzyl) in numerous types of essential oils, resins, and balsams, including cinnamon oil, Peru balsam, and tolu balsam. These compounds play an essential role in various biosynthetic pathways [2][3]. Cinnamic acid and its derivatives are important for the synthesis of other significant compounds and serve as precursors for the production of commercially valuable cinnamic esters in the perfume, cosmetic, and pharmaceutical industries [4][5]. Cinnamic acid and its derivatives exhibit a wide range of biological activities. This compound can inhibit the growth of various bacterial and fungal species. Furthermore, it possesses antioxidant, liver-protective, anti-anxiety, insect-repelling, anti-diabetic, and cholesterol-lowering properties. Cinnamic acid derivatives are highly versatile and have been used in a variety of medications. Cinnamic acid derivatives have a variety of pharmacology characteristics that include anti-TB, antioxidant, anticancer, anti-inflammatory, antidiabetic, and anticholesterol properties [2]. Several cinnamic acid esters have been shown to be anticancer, anti-inflammatory, and sunscreen [7]. Traditionally, aromatic aldehydes and active ethylene compounds are combined with organic or inorganic bases to create derivatives of cinnamic acid. Condensation of aldehydes with malonic acid in various ester derivatives is used in the pharmaceutical field[8-9]. The reported synthesis of cinnamic acid with thionyl chloride yields acid halide. Alcohol and this acid halide can react to produce cinnamic esters, often known as cinamoil esters. This acid halide can combine with alcohol to form cinnamic esters (cinamoil esters). Several cinnamic esters from Dutch propolis, including benzyl caffeine, phenethyl caffeine, and cinnamoyl caffeine, have anti-

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proliferative properties against cancer 26L5 with EC50 values of 0.288, 0.176, and 0.114 g/mL, respectively. Phenethylcaffeine (caffeic acid phenethyl ester, CAPE) has a variety of biological actions, including antioxidant, anti-inflammatory, and tumor growth inhibition [7]. In that order. Phenethylcaffeine (caffeic acid phenethyl ester, CAPE) has a variety of biological actions, including antioxidant, anti-inflammatory, and tumor growth inhibition [7].

Cinnamic acid-derived chemicals are found in practically all plants, but the quantity is minimal, thus it cannot be based solely on results obtained from extraction or isolation of plant parts. Chemical synthesis can be used to increase production of cinnamic acid derivative compounds [10]. Ethyl cinnamate is one of the cinnamon compounds that can be produced. Using a natural zeolite hierarchical-mesoporous system catalyst, cinnamic acid and ethanol can undergo an esterification reaction to create this chemical. One easy way to convert organic acids—in this example, carboxylic acids—into ester derivative chemicals is esterification. One easy way to convert organic acids—in this example, carboxylic acids—into ester derivative chemicals is esterification. Sulfuric acid is frequently used in esterification with catalytic acid assistance [10]. The use of homogeneous catalysts, such as sulfuric acid, typically has drawbacks, including being challenging to separate, caustic, and sometimes environmentally harmful. Zeolite modification as a heterogeneous, green catalyst is anticipated to be able to develop into an alternative catalyst in compound chemistry, a novel, capable system that speeds up reactions using the notion of renewability and reusability. The hierarchical-mesoporous forming mechanism was used for the modification. This substance is an ester of cinnamic acid and ethanol, a saturated alcohol.

Several methods exist for synthesizing cinnamate derivatives, including reflux [11] and microwave irradiation [12]. This type of synthesis demands a long reaction time, high temperatures, and high pressure. The standard method's drawbacks include a lengthy time, high temperature, and pressure, therefore an alternate approach for synthesizing cinnamate and its derivatives that can overcome the limitations of the conventional method is known as the ultrasonication method (aided by ultrasonic waves) [13].

Ultrasonication processes have emerged as a green chemistry option in this century because to its simplicity, efficiency, high yields, low turnaround time, and environmental friendliness [5-14-15]. In addition, employing safe compounds can help to avoid the usage of volatile substances and harmful solvents [15].

This study is conducted using ethyl cinnamate and an ultrasonic wave, which have been shown to have antioxidant activity in vitro. The produced compounds were analyzed for structure using an infrared spectrophotometer and GC-MS.

2. Method

Chemicals

The materials used in this research include zeolite, cinnamic acid (pa, Merck), sulfuric acid (pa, Merck), methanol (pa, Merck), DPPH (pa, Sigma-Aldrich), ether (pa, Merck), ethyl acetate (pa, Merck), n-hexane (pa, Merck), ether (pa, Merck), ethanol (pa, Merck), chloroform (pa, Merck), anhydrous NaHCO₃ (pa, Merck), Anhydrous MgSO₄ (pa, Merck), silver nitrate (pa, Merck), sodium hydroxide (pa, Merck), ammonium chloride (pa, Merck), aquadest

Instrumentation

The reactor for the synthesis used the Ultrasonic Homogenizer Pulse 650 (Benchmark). Evaporator, melting point apparatus. The Infrared spectrum was measured using ATR-FTIR using carry 630 Agilent Technology at Semarang Pharmaceutical College. The melting point was measured using an electrothermal melting point. XRD (X-ray diffraction) Bruker D2 Phaser, SAA (Surface Area Analyzer) Quantachrome Novatouch Lx4, SEM-EDX JEOL JSM-6510LA

Procedure Synthesis of Ethyl Cinnamate

The synthesis of ethyl cinnamate was carried out using an esterification process based on Mutiara et al.'s (2022) research method with minor modifications. Cinnamic acid (0.04215 mol) was poured to a beaker glass, along with 100 mL of ethanol and 2.5 grams of hierarchical-mesoporous zeolite. The mixture was homogenized and sonicated for 2 h. The solution and zeolite were separated by filtering the mixture with filter paper. Saturated anhydrous NaHCO₃ was added to the solution until the pH was 7. It was then moved to a separate funnel, and ether was added. The separating funnel separated the aqueous phase (bottom phase) from the ether phase (top phase). The top phase was taken and anhydrous MgSO₄ was added, which was shaken for 5 min before being allowed to stand for 20 min. After

filtering and evaporating the mixture, the resultant filtrate—the ethyl cinnamate product—was weighed to determine the yield. The synthesized chemical was then examined in vitro for organoleptic, solubility, FTIR-ATR, GC-MS, and sunscreen activities.

Ethyl Cinnamate Characterization

The precipitate obtained was tested for melting point using a melting point apparatus. The synthesized structures were characterized using FT-IR and GC-MS

Antioxidant Test by in Vitro activities

The antioxidant molecules produced were determined using the DPPH method described by Ahmed et al. (2013), with minor modifications. The synthesized chemical was dissolved in ethanol to a concentration of 1,000 ppm. These solutions produced a series of 10 ppm, 20 ppm, 30 ppm, 40 ppm, and 50 ppm. Each solution series was pipetted 2.0 mL with 1 mL of 0.4 mM DPPH solution. The mixture was incubated in a dark room for 30 min before measuring absorbance at 515 nm wavelength. The blank is measured at the same wavelength as the sample, but the sample is excluded from the measurement. The absorbance acquired from analyzing the antioxidant percentage activity. With the first linier.

$$\%inhibisi = \frac{A_{blanko} - A_{sampel}}{A_{blanko}} \times 100\%$$

3. Results and Discussion

The synthesis compound of ethyl cinnamate in this study was obtained through an esterification reaction between cinnamic acid (0.04215 mol) with 100 mL methanol and 2.5 grams of hierarchical-mesoporous zeolite through ultrasonic wave-assisted ultrasonication methods[14][8]. The Reaction can be seen in figure 1.

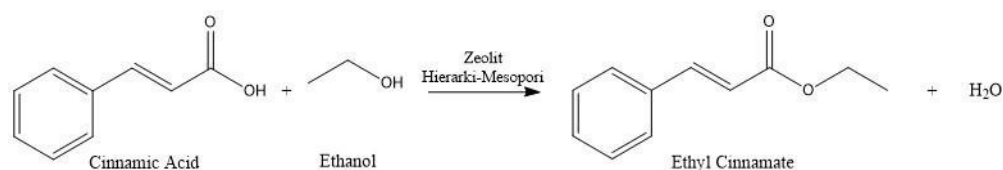


Figure 1. Esterification Reaction On Cinnamic Acid With Ethanol.

The synthesis of these compounds is carried out with ultrasonic waves help in a sonicator. Ultrasonic irradiation would increase the reaction between cinnamic acid and ethanol through cavitation mechanism[16]. Percent yield produce at 2 h is 36,36%. The results of the organoleptic test showed that the synthesized compound was a liquid, pale yellow, cinnamon like odor and had a melting point on 6°C-8°C.

The results test of structural elucidation by using FT IR spectrophotometry can be seen in Figure 2.

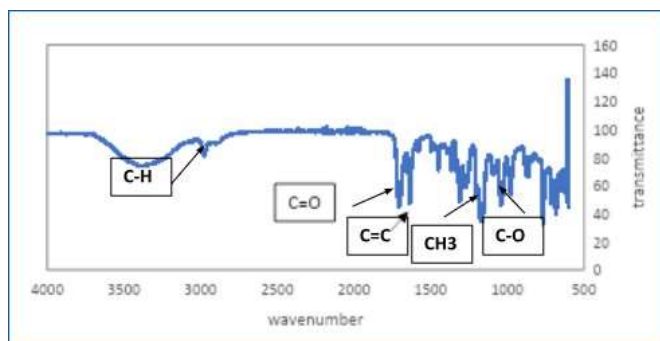


Figure 2. Spectrum FTIR From Ethyl Cinnamate.

The infrared spectra of the synthesised ethyl cinnamate molecule reveal characteristic absorption of functional groups. The absorption observed is compared to the absorption of the ethyl cinnamate chemical in the work of Djuhariah and Kardono, (2024). The absorption band at 1695 cm⁻¹ confirms the existence of a carbonyl group (C=O) ester, which is the

primary feature of ethyl cinnamate synthesis, and falls within the 1710-1720 cm^{-1} range reported in the literature. The presence of this group is the primary indicator that the esterification reaction between cinnamic acid and methanol has occurred. Furthermore, the absorption band at wave number 1251-1036 cm^{-1} corresponds to the stretching vibration (C-O) ester, which strengthens the production of an ester group in the compound structure. The absorption at 1589-1535 cm^{-1} reveals the existence of an aromatic C=C group from the benzene ring within the ethyl cinnamate structure. The absorption band at 1634 cm^{-1} confirms the presence of a double bond of C=C alkene originating from the propenyl chain ($-\text{CH}=\text{CH}-\text{COOCH}_3$), indicating that the conjugation structure between the aromatic ring and alkene bond is preserved during synthesis. The absorption band at 2889-2997 cm^{-1} suggests aliphatic C-H stretching vibration from ethyl ester group ($-\text{OCH}_3$). The absorption range of 3034-3089 cm^{-1} corresponds to the aromatic C-H stretching vibration of benzene rings, which is consistent with the literature range of 3250-3050 cm^{-1} . In addition, the absorption in the 1450-1367 cm^{-1} area demonstrates the bending vibration of the $-\text{CH}_3$ group, which is in conformity with the literature range of 1450-1375 cm^{-1} , confirming the presence of a methoxy group in the ethyl cinnamate structure.

The synthesized ethyl cinnamate was then evaluated using GC-MS to determine the synthesis of the target molecule and the product's purity. The mass spectrometry method works by first converting the sample to a gaseous state, after which the molecules are ionized by bombarding them with high-energy electrons, resulting in the release of an electron and the formation of an unstable radical cation. This radical cation is subsequently broken down into simpler ion fragments with a distinct pattern determined by its molecular structure. The chromatogram of the synthesized ethyl cinnamate chemical demonstrates that the product obtained contains the target compound, as evidenced by the presence of the largest peak in the TIC (Total Ion Current) chromatogram. The chromatogram of the GC-MS analysis of ethyl cinnamate revealed a prominent peak with a retention time of 27,181 min, with a compound abundance of 99,81%. This abundance number shows that ethyl cinnamate is the primary component of the produced product.

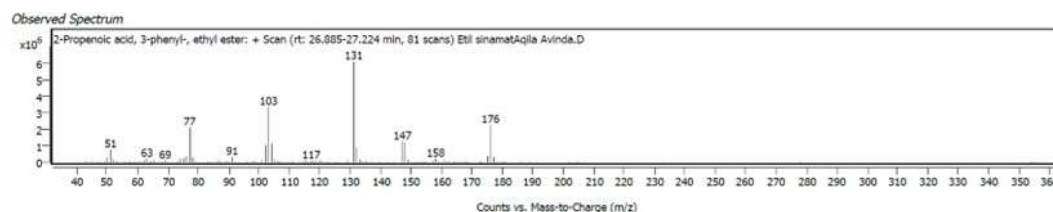


Figure 3. Mass Spectra of ethyl cinnamate compound.

The target compound structure was identified by interpreting the mass spectrum of the synthesized product and comparing it to the mass spectrum of the NIST23 library reference.

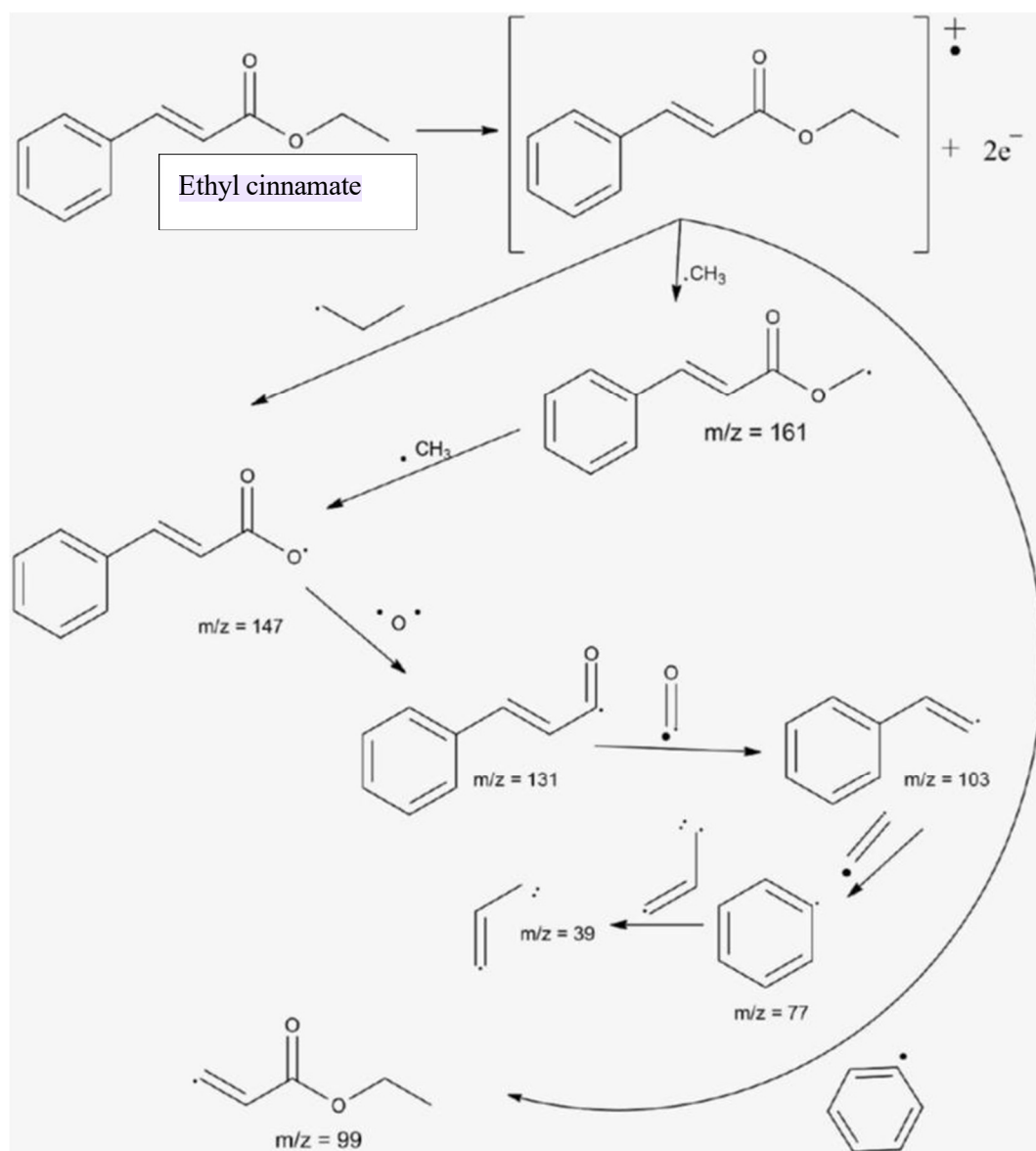


Figure 4. Fragmentation of Ethyl Cinnamate.

Furthermore, the mass spectrum fragmentation of ethyl cinnamate generally begins with the formation of the molecular ion radical ($M^+\bullet$) through electron impact ionization. Ethyl cinnamate has a molecular weight of 176, therefore the molecular ion appears at m/z 176. The molecular ion undergoes cleavage of a methyl radical ($\bullet\text{CH}_3$) from the ethoxy group: ($-\text{CH}_3$, -15 m/z). Further fragmentation occurs through cleavage of the ethyl group ($\bullet\text{C}_2\text{H}_5$) from the ester moiety ($-\text{C}_2\text{H}_5$, -29 m/z). The resulting ion is a resonance-stabilized cinnamoyl ester fragment. The ion at m/z 147 subsequently loses an oxygen atom or undergoes rearrangement to produce the cinnamaldehyde-type fragment ion ($-\text{O}$, -16 m/z). This ion remains stabilized by conjugation between the phenyl ring and the double bond. The fragment at m/z 131 loses carbon monoxide ($-\text{CO}$, -28 m/z). The ion at m/z 103 corresponds to a styrene-like benzyl fragment. Further cleavage of the side chain generates the highly stable phenyl cation. The peak at m/z 77 appears to represent the phenyl ion (C_6H_5^+), a distinctive fragment of aromatic compounds that develops after the side chain on the benzene ring is entirely freed. The phenyl ion may undergo additional ring fragmentation to produce smaller hydrocarbon ions. This fragment is commonly assigned to the propargyl or allylic cation. Cleavage on the ester side chain can also generate an alkoxycarbonyl fragment ($\text{CH}_2=\text{CHCOOC}_2\text{H}_5$, -77 m/z).

The DPPH technique is an effective way to assess antioxidant effectiveness in vitro [17]. It was done to assess the antioxidant activity of the synthetic substances [18]. The antioxidant activity test method is quantitative, evaluating the DPPH radical capture by one of the compounds with antioxidant activity using UV-Vis spectrophotometry, therefore the value of free radical activity will be known with IC50 values (inhibitory concentration)[19]. The

DPPH radical antidote activity of the synthesized compound was compared to ascorbic acid at the same concentration, with the antioxidant measure represented as percentage DPPH radical inhibition. The radical reduction of DPPH was evaluated by measuring its absorbance at 515.4 nm. The following table is the outcome of testing the antioxidant activity of synthesized chemicals spectrophotometrically.

Table 1. Antioxidant Activity Ethyl Cinnamate.

Concentration µg/mL	Absorbance	% Inhibition	Equality $y = bx + a$	EC50 µg/mL
Control	0,801	0		
30,030	0,612	23,60		
60,060	0,522	34,83	$y = 0,4128x + 10,4744$ $R^2 = 0,9985$	95,74
90,090	0,431	46,19		
120,120	0,309	61,42		
150,150	0,222	72,28		

Based on the results of table 1 above, the EC50 value of the synthesized ethyl cinnamate compound was calculated using the linear equation g/mL, implying that the antioxidant activity of the produced compound was high. It is demonstrated that as the concentration of the produced molecule grows, so does the percentage of inhibition. As a result, it is reasonable to believe that compound ethyl cinnamate possesses substantial antioxidant activity comparable to positive controls. The produced chemical has substantial antioxidant activity because it is a derivative of cinnamic acid that is more active than its precursor compound. This is due to the addition of an ethyl group with a longer chain, which causes allosteric characteristics to occur faster than their precursor, increasing antioxidant activity [18]. The molecule ethyl cinnamate was soluble in organic solvents but insoluble in water, implying that it possesses certain lipophilic properties, resulting in stronger antioxidant activity than its precursor [17-18].

4. Conclusions

Ethyl cinnamate can be produced through an esterification reaction between cinnamic acid and ethanol, utilizing a natural zeolite hierarchical-mesoporous system as a catalyst with ultrasonication method. The antioxidant activity, represented by the EC50 value of the synthesized ethyl cinnamate compound, was found to be 95,74, categorizing it in the strong range.

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Data Availability Statement: The authors confirm that all data underlying the results presented in this work are included within the article. Additional raw datasets related to the study can be obtained from the corresponding author upon reasonable request.

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References

- [1] N. Kumar and A. Parle, "Cinnamic acid derivatives : An ERA," *Pharma Innov. J.*, vol. 8, no. 5, pp. 580–595, 2019, doi : <https://www.doi.org/10.22271/tpi.2019.v8.i3j.25396>.
- [2] P. Sharma, "Cinnamic acid derivatives: A new chapter of various pharmacological activities," *J. Chem. Pharm. Res.*, vol. 3, no. 2, pp. 403–423, 2011.
- [3] A. F. Masduqi, E. Indriyanti, and R. S. Dinurrosifa, "Antibacterial Activity Testing on APMS (p - Methoxy Cinnamic Acid) Against Escherichia coli Bacteria Uji Aktivitas Antibakteri Senyawa APMS (Asam p _ Metoksi Sinamat) Terhadap Bakteri Escherichia coli," vol. 21, no. 2, pp. 155–160, 2021, doi : <https://www.doi.org/10.35799/jis.v21i2.35684>.
- [4] J. D. Guzman, "Natural cinnamic acids, synthetic derivatives and hybrids with antimicrobial activity," *Molecules*. 2014, doi: 10.1093/mp/ssp106.
- [5] E. Indriyanti and M. S. Prahasiwi, "Synthesis Of Cinnamic Acid Based On Perkin Reaction Using Ultrasonication Method And Its Potential As Photoprotective Agent," vol. 5, no. 1, pp. 54–61, 2020.
- [6] M. Sova, "Antioxidant and Antimicrobial Activities of Cinnamic Acid Derivatives," *Mini-Reviews Med. Chem.*, 2012, doi : <https://doi.org/10.2174/138955712801264792>.
- [7] K. Zhou, D. Chen, B. Li, B. Zhang, F. Miao, and L. Zhou, "Bioactivity and structure-activity relationship of cinnamic acid esters and their derivatives as potential antifungal agents for plant protection," *PLoS One*, vol. 12, no. 4, 2017, doi : <https://doi.org/10.1371/journal.pone.0176189>.
- [8] J. S. Ghomi and Z. Akbarzadeh, "Ultrasonic accelerated Knoevenagel condensation by magnetically recoverable MgFe₂O₄ nanocatalyst: A rapid and green synthesis of coumarins under solvent-free conditions," *Ultrason. Sonochem.*, vol. 40, pp. 78–83, 2018, doi : <https://doi.org/10.1016/j.ultsonch.2017.07.03>.
- [9] R. D. C. Da Silveira E Sá, L. N. Andrade, R. D. R. B. De Oliveira, and D. P. De Sousa, "A review on anti-inflammatory activity of phenylpropanoids found in essential oils," *Molecules*, vol. 19, no. 2, pp. 1459–1480, 2014, doi : <https://doi.org/10.3390/molecules19021459>.
- [10] L. O. Kadidae, R. Ruslin, L. Nurliana, and L. A. Kadir, "Sintesis Ester Asam Sinamat Menggunakan Variasi Katalis Asam," *J. Pijar Mipa*, vol. 15, no. 3, p. 240, 2020, doi : <https://doi.org/10.29303/jpm.v15i3.1779>.
- [11] N. Hidajati and Suyatno, "Sintesis Senyawa Tabir Matahari n-Oktil Para-Metoksi Sinamat Menggunakan Material Awal Etil Para-Metoksi Sinamat Hasil Isolasi dari Rimpang Kencur (Kaemferia galanga L .) Synthesis of a Sunscreen Compound n-Octyl Para-Menthoxo Cinnamat using Ethyl Para- M," *J. Ilmu Dasar*, vol. 9, no. 1, pp. 22–27, 2008.
- [12] I. Komala et al., "Microwave assisted synthesis of p-methoxycinnamamides and p-methoxy-β- nitrostyrenes from ethyl p-methoxycinnamate and screening their anti-inflammatory activity," *Nat. Prod. Commun.*, vol. 12, no. 8, pp. 1265–1268, 2017, doi : <https://doi.org/10.1177/1934578X1701200822>.
- [13] M. Draye, G. Chatel, and R. Duwald, "Ultrasound for drug synthesis: A green approach," *Pharmaceuticals*, vol. 13, no. 2, 2020, doi : <https://doi.org/10.3390/ph13020023>.
- [14] P. N. K. Babu, B. R. Devi, and P. K. Dubey, "Ultrasound assisted convenient, rapid and environmentally benign synthesis of N-alkylbenzimidazoles," *Der Chem. Sin.*, vol. 4, no. 1, pp. 105– 110, 2013.
- [15] B. R. Patel □ , D. H. Desai, J. P. Raval, and B. R. Patel, "Green Efficient Synthesis of Aryl Thioamides Using Ultrasound: A Comparative Study," *J. Pharm. Appl. Sci.*, vol. 1, no. 1, pp. 29–33, 2014.
- [16] N. Sharma, P. Kumari, P. Sharma, N. Bhagat, and S. Bhagat, "Ultrasound-Accelerated Amide Coupling Reactions Directed toward the Synthesis of 1-Acetyl-3-carboxamide-β-carboline Derivatives of Biological Importance," *SynOpen*, vol. 1, no. 1, pp. 8–10, 2017, doi : <https://doi.org/10.1055/s-0036-1589482>.
- [17] S. B. Nimse, D. Pal, A. Mazumder, and R. Mazumder, "Synthesis of Cinnamanilide Derivatives and Their Antioxidant and Antimicrobial Activity," *J. Chem.*, vol. 2015, pp. 1–6, 2015, doi : <https://doi.org/10.1155/2015/709476>.
- [18] O. H. Oladimeji, "Acetylation of Cinnamic Acid and Evaluation of Antioxidant Activity of the Resultant Derivative," *Biomed. J. Sci. Tech. Res.*, vol. 39, no. 2, pp. 31085–31088, 2021, doi : <https://doi.org/10.26717/BJSTR.2021.39.006287>.
- [19] S. W. Ery Al Ridho, Rafika Sari, "Uji Aktivitas Antioksidan Ekstrak Metanol Buah Lakum (Cayratia trifolia) Dengan Metode DPPH (2,2-Difenil-1-Pikrilhidrazil)," *Ery Al Ridho, Rafika Sari, Sri Wahdaningsih*, vol. 26, no. 4, pp. 185–197, 2013.
- [20] D. B. R. Ramalingam1*, B. Bindu Madhavi1, A. Ravinder Nath1, N. Duganath2, E. Udaya Sri2 and IFaculty, "In-vitro anti-denaturation and antibacterial activities of Zizyphus oenoplia," *Sch. Res. Libr.*, vol. 2, no. 4, pp. 373–383, 2011.
- [21] D. R. Laksmiawati and C. Tiffani, "Aktivitas Penghambatan Denaturasi Albumin dan Efek Anti- Inflamasi Campuran Ekstrak Herba Meniran, Daun Kelor, Daun Salam," *Maj. Farmasetika.*, vol. 4, no. Suppl 1, pp. 233–239, 2020, doi : <https://doi.org/10.24198/mfarmasetika.v4i0.25860>.
- [22] J. A. Whittaker and B. Vogler, "The in vitro Anti-denaturation Effects Induced by Natural Products and Non- steroidal Compounds in Heat Treated (Immunogenic) Bovine Serum Albumin is Proposed as a Screening Assay f ... The in vitro Anti-denaturation Effects Induced by Natural Products and Non- steroidal Compounds in Heat Treated (Immunogenic) Bovine Serum Albumin is Proposed as aScreening Assay for the Detection of Anti-inflammatory Compounds , without the use of Animals , in the Early Stages of the Drug Discovery Process Los Efectos de la Anti-desnaturalización in vitro Inducida por Productos Naturales y Compuestos no Esteroidales en la Albúmina Sérica Bovina (Inmunogénica) Tratada con Calor , se Proponen aquí como Ensayo de Pesquiza je para la Detección de Compuestos Inflamatorios sin el uso de Animales en las Etapas Tempranas del Proceso de Descubrimiento del Medicamento," no. October, 2008.
- [23] I. Komala et al., "Structure-Activity Relationship Study on the Ethyl p -Methoxycinnamate as an Anti- Inflammatory Agent," vol. 18, no. 1, pp. 60–65, 2018, doi : <https://doi.org/10.22146/ijc.28795>.