BAB 5
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Dari penelitian yang sudah dilakukan, dapat disimpulkan:

1. Senyawa 2,6-bis((*E*)-4-hidroksi-3-metoksibenziliden)sikloheksan-1-on dapat di sintesis menggunakan metode iradiasi gelombang mikro.
2. Reaksi dari 4-hidroksi-3-metoksibenzaldehid dan sikloheksanon dalam katalis asam dengan bantuan iradiasi gelombang mikro pada daya 480 W selama 17 menit menghasilkan senyawa 2,6-bis((*E*)-4-hidroksi-3-metoksibenziliden)sikloheksan-1-on dengan rendemen 48,58% ± 5,46%.
3. Reaksi dari 4-hidroksi-3-metoksibenzaldehid dan sikloheksanon dalam katalis asam dengan metode konvensional dengan pemanasan 50^{o}C dan pengadukan selama 90 menit menghasilkan senyawa 2,6-bis((*E*)-4-hidroksi-3-metoksibenziliden)siklo-heksan-1-on dengan rendemen 43,83% ± 5,03%.
4. Ditinjau dari rendemen hasil, dari uji statistik metode iradiasi gelombang mikro (48,58% ± 5,46%) tidak berbeda bermakna dengan konvensional (43,83% ± 5,03%), namun dari lama waktu reaksi iradiasi gelombang mikro lebih efisien.

5.2 Saran

1. Apabila hendak dilakukan penelitian kembali, dapat dilakukan sintesis menggunakan iradiasi gelombang mikro pada daya yang lebih rendah.

2. Menambahkan jumlah mol HCl yang digunakan dari 2 mmol menjadi 4 mmol untuk metode iradiasi gelombang mikro dan konvensional.
3. Dapat dilakukan uji aktivitas sebagai penghambat proliferasi sel 4T1 terhadap senyawa hasil.

DAFTAR PUSTAKA

Abdul-rida, N. A. and Hassouni, A. H., 2022, Synthesis, spectral studies of some new chalcone and schiff base derivatives derived from cyclohexanone and molecular docking and biological activity studies, *Journal of Pharmaceutical Negative Results*, **13(3)**: 1134–1151.

Aher, R. B., Wanare, G., Kawathekar, N., Kumar, R. R., Kaushik, N. K., Sahal, D. and Chauhan, V. S., 2011, Dibenzylideneacetone analogues as novel *Plasmodium falciparum* inhibitors, *Bioorganic and Medicinal Chemistry Letters*, **21(10)**: 3034–3036.

Armarego, W. L. F., 2003, *Purification of Laboratory Chemicals*, 5th eds., Butterworth Heinemann, Australia.

Arya, S. S., Rookes, J. E., Cahill, D. M. and Lenka, S. K., 2021, Vanillin: A review on the therapeutic prospects of a popular flavouring molecule, *Advances in Traditional Medicine*, **21(3)**: 415–431.

Bhullar, K. S., Jha, A., Youssef, D. and Rupasinghe, H. P. V., 2013, Curcumin and its carbocyclic analogs: Structure-activity in relation to antioxidant and selected biological properties, *Molecules*, **18**: 5389–5404.

Budiati, T., Soewandi, A. and Soegianto, L., 2019. Research article microwave-assisted synthesis of dibenzalacetone derivatives and study of their potential antioxidant activities, *Journal of Chemical and Pharmaceutical Research*, **11(9)**: 11–16.

Budimarwanti, C. and Handayani, S., 2010, Efektivitas katalis asam basa pada sintesis 2-hidroksikalkon senyawa yang berpotensi sebagai zat warna, Prosiding Seminar Nasional Kimia dan Pendidikan Kimia.

Carey, F. A. and Sundberg, R. J., 2007, *Advanced Organic Chemistry*, 5th eds., Part A: Structure and Mechanisms, Springer, USA.

Ciciliato, M. P., de Souza, M. C., Tarran, C. M., de Castilho, A. L. T., Vieira, A. J. and Rozza, A. L., 2022, Anti-inflammatory effect of vanillin protects the stomach against ulcer formation, *Pharmaceutics*, **14(755)**: 1–11.

Das, A. and Banik, B. K., 2021, *Microwaves in Chemistry Applications: Fundamentals, Methods and Future Trends*, ElSevier, USA.

Davoodnia, A. and Yassaghi, G., 2012, Solvent-free selective cross-aldol condensation of ketones with aromatic aldehydes efficiently catalyzed by a reusable supported acidic ionic liquid, *Chinese Journal of Catalysis*, **33(12)**: 1950–1957.

Dibbern, H. W., Muller, R. M. and Wirbitzki, E., 2002, *UV and IR Spectra: Pharmaceutical Substances (UV and IR) and Pharmaceutical and Cosmetic Excipients (IR)*, Editio Cantor Verlag / Aulendorf (Germany).

Du, Z. Y., Bao, Y. D., Liu, Z., Qiao, W., Ma, L., Huang, Z. S., Gu, L. Q. and Chan, A. S. C., 2006, Curcumin analogs as potent aldose reductase inhibitors. *Archiv der Pharmazie*, **339(3)**: 123–128.

Ehsan, M. and Chowdhury, M. T. H., 2015, Production of biodiesel using alkaline based catalysts from waste cooking oil: A case study, *Procedia Engineering*, **105**: 638–645.

Eryanti, Y., Nurulita, Y., Hendra, R., Yuharmen, Y., Syahri, J. and Zamri, A., 2011, Synthesizing derivatives from cyclopentanone analogue curcumin and their toxic, antioxidant and anti-inflammatory activities, *Makara Journal of Science*, **15(2)**: 117–123.

Fajri, A. N. dan Handayani, S. 2017. Sintesis 2-(3'-hidroksibenziliden)sikloheksanon melalui reaksi Claisen-Schmidt antara 3-hidroksibenzaldehida dan sikloheksanon menggunakan metode MAOS. *Jurnal Penelitian Saintek*, **22(2)**: 67–79.

Fasya, A. G., Hanapi, A. and Ningseh, R. A. P., 2014, Sintesis senyawa 4-hidroksi-3-metoksi-5-(fenildiazenil) benzaldehida dan uji aktifitas antioksidannya terhadap DPPH, *Alchemy*, **3(2)**: 101–107.

Fatoni, A., Hariani, P. L., Hermansyah and Lesbani, A., 2018, Synthesis and characterization of chitosan linked by methylene bridge and schiff base of 4,4-diaminodiphenyl ether-vanillin, *Indonesian Journal of Chemistry*, **18(1)**: 92–101.

Felton, L., 2013, *Remington: Essentials of Pharmaceutics*, Pharmaceutical Press, India.

Garg, S. and Garg, A., 2018, Encapsulation of curcumin in silver nanoparticle for enhancement of anticancer drug delivery, *International Journal of Pharmaceutical Sciences and Research*, **9(3)**: 1160–1166.

Görög, S., 1995, *Ultraviolet-Visible Spectrophotometry in Pharmaceutical Analysis*, CRC Press, New York.

Handayani, S., Arty, I. S. and Arianingrum, R., 2006, The study of crossed aldol condensation at the synthesis of asymmetric dibenzalacetone, *Pure and Applide Chemistry International Conference*, 388–389.

Handayani, S. and Arty, I. S., 2008, Synthesis of hydroxyl radical scavengers from benzalacetone and its derivatives, *Journal of Physical Science*, **19(2)**: 61–68.

Handayani, S., Matsjeh, S., Anwar, C., Atun, S. and Fatimah, I., 2012, Noven synthesis of 1,5-dibenzalacetone using NaOH/ZrO2-montmorillonite as cooperative catalyst, *International Journal of Chemical and Analytical Science*, **3(6)**: 1419–1424.

Handayani, S., Budimarwanti, C. and Haryadi, W., 2017, Microwave-assisted organic reactions: Eco-friendly synthesis of dibenzylidenecyclohexanone derivatives via crossed aldol condensation, *Indonesian Journal of Chemistry*, **17(2)**: 336–341.

Hayakawa, H., Minaniya, Y., Ito, K., Yamamoto, Y. and Fukuda, T., 2011, Difference of curcumin content in *Curcuma longa* L. (Zingiberaceae) caused by hybridization with other Curcuma species, *American Journal of Plant Sciences*, **2(2)**: 111–119.

Hayun, H., Maggadani, B., P., Kurnia, A., Hanifah, A., Yuliandi, M., Fitriyani, I. And Hadrianti, S. P., 2019, Anti-inflammatory and antioxidant activity of synthesized mannich base derivatives of (2e,6e)-2-[(4-hydroxy-3-methoxyphenyl)methylidene]-6-(phenyl methylidene)cyclohexan-1-one, *International Journal of Applied Pharmaceutics*, **11(1)**: 246–250.

Hocking, M. B., 2005, Commercial polycondensation (step-growth) polymers, *Handbook of Chemical Technology and Pollution Control*, 689–712.

Jessica, J., Budiati, T. and Caroline, C., 2021, Sintesis dan uji aktivitas antioksidan senyawa 4,4'-dinitrodibenzalaseton dengan Metode DPPH, *Journal of Pharmacy Science and Practice*, **8(2)**: 62–68.

Kappe, C. O. and Stadler, A., 2005, *Microwaves in Organic and Medicinal Chemistry*, Wiley-VCH, Weinheim.

Kementrian Kesehatan Republik Indonesia, 2020, *Farmakope Indonesia edisi V*, Kementrian Kesehatan Republik Indonesia, Jakarta.

Liang, G., Shao, L., Wang, Y., Zhao, C., Chu, Y., Xiao, J., Zhao, Y., Li, X. and Yang, S., 2009, Exploration and synthesis of curcumin

analogues with improved structural stability both in vitro and in vivo as cytotoxic agents, *Bioorganic and Medicinal Chemistry*, **17**: 2623–2631.

Lu, K, T., Luo, K.M., Lin, S. H., Su, S. H. and Hu, K. H., 2004, The acid-catalyzed phenol-formaldehyde reaction critical runaway conditions and stability criterion. *Process Safety and Environmental Protection*, **82(1)**: 37–47.

Mahalakshmi, S., Sruthi, V. S., Babu, N. G., R., Sivaraj, C. and Arumugam, P., 2019, Isolation and pharmacological activities of curcumin from *Curcuma longa* L., *International Journal for Research in Applied Sciences and Biotechnology*, **6(5)**: 7–17.

Mardianis, Y., Anwar, C. and Haryadi, W., 2017, Synthesis of curcumin analogues monoketone from cinnamaldehyde and their inhibition assay against alpha-glucosidase enzyme, *Materials Science Forum*, **901**: 110–117.

Martha, R. D., Wahyuningsih, T. D. dan Anwar, C., 2020, Sintesis analog kurkumin 2,6-bis-(E)-4-hidroks-3-metoksibenzilidin)-sikloheksa-1-on berbahan dasar vanilin dengan katalis HCl, *Jurnal Penelitian Saintek*, **25(2)**: 195–204.

McMurry, J., 2016, *Organic Chemistry*, 9th eds., Thomson Brooks/Cole, United States.

Mirafzal, G. A. and Summer, J. M., 2000, Microwave irradiation reactions: Synthesis of analgesic drugs, *Journal of Chemical Education*, **77(3)**: 356–357.

Murtisiwi, L., 2012, Sintesis 2,5-bis(4-hidroksibensilidin)siklopentanon dari p-hidroksibenzaldehid dan siklopentanon dengan katalis asam sulfat, *Journal of Pharmacy*, **1(1)**: 1–12.

Mutiah, R., 2015, Evidence based kurkumin dari tanaman kunyit (*Curcuma longa*) sebagai terapi kanker pada pengobatan modern, *Jurnal Farma Sains*, **1(1)**: 28–41.

Nakhjiri, M., Safavi, M., Alipour, E., Emami, S., Atash, A. F., Jafari-Zavareh, M., Ardestani, S. K., Khoshneviszadeh, M., Foroumadi, A. and Shafiee, A., 2012, Asymmetrical 2,6-bis(benzylidene)cyclohexanones: Synthesis, cytotoxic activity and QSAR study. *European Journal of Medicinal Chemistry*, **50**: 113–123.

Nocito, M. C., De Luca, A., Prestia, F., Avena, P., La Padula, D., Zavaglia, L., Sirianni, R., Casaburi, I., Puoci, F., Chimento, A. and Pezzi, V., 2021, Antitumoral activities of curcumin and recent advances to improve its oral bioavailability, *Biomedicines*, **9**: 1–38.

O'Neil, M. J., 2001, The Merck Index: An Encyclopedia of Chemicals, Drugs, and Biologicals, 13th eds., Merck and Co, USA.

Patil, M. B., Taralkar, S. V., Sakpal, V. S., Shewale, S. P. and Sakpal, R. S., 2011, Extraction, isolation and evaluation of anti-inflammatory activity of curcuminoids from *Curcuma longa*, *International Journal Of Chemical Sciences and Applications*, **2(3)**: 172–174.

Pavia, D. L., Lampman, G. M., Kriz, G. S. and Vyvyan, J. R., 2009, *Introduction to Spectroscopy 4th eds*., Brooks/Cole Cengange Learning, United States of America.

Purwanto, P. dan Hardjono, S., 2016, 'Hubungan struktur, ikatan kimia dan aktivitas biologis obat' dalam Siswandono, S., *Kimia Medisinal edisi kedua*, Airlangga University Press, Surabaya, hal. 227-244.

Puteri, E. R. dan Handayani, S., 2017, Pengaruh variasi rasio mol 4-metoksibenzaldehida dan sikloheksanon pada sintesis 2-(4'-metoksibenziliden)sikloheksanon menggunakan metode Microwave Assisted Organic Synthesis, *Jurnal Penelitian Saintek*, **22(1)**: 25–36.

Rahman, A. F. M. M., Ali, R., Jahng, Y. and Kadi, A. A., 2012, A facile solvent free claisen-schmidt reaction: Synthesis of α,α'-bis-(substituted-benzylidene)cycloalkanones and α,α'-bis-(substituted-alkylidene)cycloalkanones, *Molecules*, **17**: 571–583.

Rahmawati, E. N., Teruna, H. Y. and Zhamri, A., 2018, Sintesis dan uji toksisitas senyawa analog kurkumin 3,5-bis((*E*)-metoksibenziliden)-1-(fenilsulfonil)-piperidin-4-on, *Jurnal Photon*, **9(1)**: 151–158.

Rayar, A., Veitía, M. S. I. and Ferroud, C., 2015, An efficient and selective microwave-assisted Claisen-Schmidt reaction for the synthesis of functionalized benzalacetones. *SpringerPlus*, **4(221)**: 1–5.

Razak, N. A., Akhtar, M. N., Abu, N., Ho, W. Y., Tan, S. W., Zareen, S., Taj-Ud-Din, S. N. Bin, Long, K., Alitheen, N. B. and Yeap, S. K., 2017, The in vivo anti-tumor effect of curcumin derivative (2E,6E)-2,6-bis(4-hydroxy-3-methoxybenzylidene) cyclohexanone (BHMC) on 4T1 breast cancer cells, *RSC Advances*, **7**: 36185–36192.

Revalde, J. L., Li, Y., Hawkins, B. C., Rosengren, R. J. and Paxton, J. W., 2015, Heterocyclic cyclohexanone monocarbonyl analogs of curcumin can inhibit the activity of ATP-binding cassette transporters in cancer multidrug resistance, *Biochemical Pharmacology*, **93(3)**: 305–317.

Rostami, A. and Ahmad-Jangi, F., 2011, Sulfamic acid: An efficient, cost-effective and green catalyst for crossed-aldol condensation of ketones with aromatic aldehydes under solvent-free, *Chinese Chemical Letters*, **22**: 1029–1032.

Salau, V. F., Erukainure, O. L., Olofinsan, K. A., Ijomone, O. M., Msomi, N. Z. and Islam, M. S., 2021, Vanillin modulates activities linked to dysmetabolism in psoas muscle of diabetic rats, *Scientific Reports*, **11(1)**: 1–18.

Sanches, N. B., Pedro, R., Diniz, M. F., Mattos, E. da C., Cassu, S. N. and Dutra, R. de C. L. 2013. Infrared spectroscopy applied to materials used as thermal insulation and coatings. *Journal of Aerospace Technology and Management*, 5(4): 421–430.

Santosa, T. A., and Yulianti, S., 2020, Identifikasi famili Zingiberaceae di kawasan hutan Gunung Bua Kerinci, *Ekologia : Jurnal Ilmiah Ilmu Dasar dan Lingkungan Hidup*, **20(2)**: 74–78.

Saunders, K. J., 1988, *Organic Polymer Chemistry*, 2nd eds., Chapman and Hall, UK.

Shriner, R. L., Hermann, C. K. F., Morril, T. C., Curtin, D. Y. and Fuson, R. C., 2004, *The Systematic Identification of Organic Compounds*, 8th eds., John Wiley and Sons, Inc., New Jersey.

Simbara, A., Sardjiman, S. and Nurkhasanah, N., 2005, Sintesa senyawa 2,5-bis(4-hidroksi-3-metoksibenzilidin)siklopentanon dengan variasi jenis pelarut, *Prosiding Semnas Penelitian, Pendidikan dan Penerapan MIPA*, 67–77.

Smith, J. G., 2011, *Organic Chemistry 3th*, McGraw Hill, New York.

Subositi, D. and Wahyono, S. 2019. Study of the genus curcuma in Indonesia used as traditional herbal medicines. *Biodiversitas*, **20(5)**: 1356–1361.

Tranter, G., 2010, UV-visible absorption spectrometers, in Lindon, J. C., *Encyclopedia of Spectroscopy and Spectrometry 2nd eds*., Elsevier, United Kingdom.

Urošević, M., Nikolić, L., Gajić, I., Nikolić, V., Dinić, A. and Miljković, V., 2022, Curcumin: Biological activities and modern pharmaceutical forms, *Antibiotics*, **11**: 1–27.

Vashishtha, M., Mishra, M. and Shah, D. O., 2013, A novel approach for selective cross aldol condensation using reusable NaOH-cationic micellar systems, *Applied Catalysis A: General*, **466**: 38–44.

Vogel, A. I., 1956, *A Textbook of Practical Organic Chemistry Including Qualitative Organic Analysis*, Logman, London.

Waleulu, M. and Soekamto, N. H., 2016, *Sintesis senyawa p-asetoksisinamat dari asam p-kumarat melalui reaksi asetilasi*.

Yadav, G. D. and Wagh, D. P., 2020, Claisen-Schmidt condensation using green catalytic processes: A critical review, *ChemistrySelect*, **5**: 9059–9085.

Zaki, N. W., Sidiq, M., Qasim, M., Aranas, B., Hakamy, A., Ruwais, N., Alanezi, H., Saudi, D. Al, Alshahrani, R. S., Al-Thomali, A. A., Manzar, M., BaHammam, A., Al-Kaabba, A. and Pandi-Perumal, S., 2020, Biological activities of bisdesmethoxycurcumin, *Journal of Nature and Science of Medicine*, **3**: 219–220.

Zulaikhah, S. T., 2017, The role of antioxidant to prevent free radicals in the body. *Sains Medika*, **8(1)**: 39–45.