

## REFERENCES

- Agnihotri, S., and Zadeh, G., 2016, Metabolic reprogramming in glioblastoma: the influence of cancer metabolism on epigenetics and unanswered questions, *Neuro-Oncology*, 18, 160-172.
- Alfarouk, K.O., Stock, C.M., Taylor, S., Walsh, M., Muddathir, A.K., Verduzco, D., Bashir, A.H., Mohammed, O.Y., Elhassan, G.O., Harguindey, S., Reshkin, S.J., Ibrahim, M.E., and Rauch, C., 2015, Resistance to cancer chemotherapy: failure in drug response from ADME to P-gp, *Cancer Cell Int.*, 15(71), doi:10.1186/s12935-015-0221-1
- Ansari, F.L., Nazir, S., Noureen, H., and Mirza, B., 2005, Combinatorial synthesis and evaluation of an indexed chalcone library, *Chem. Biodivers.*, 1656-1664.
- Badmus, J.A., Ekpo, O.E., Hussein, A.A., Meyer, M., and Hiss, D.C., 2015, Antiproliferative and Apoptosis Induction Potential of the Methanolic Leaf Extract of *Holarrhena floribunda* (G.Don) T. Durand & Schinz leaves, *Evid Based Complement Alternat Med*, 2015, 1-11.
- Bray, F., Ferlay, J., Soerjomataram, I., Siegel, R.L., Torre, L.A., and Jemal, A., 2018, Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries, *CA Cancer J Clin.*, 68, 394-424.
- Bukhari, S.N.A., Jasamai, M., Jantan, I., and Ahmad, W., 2013, Review of Methods and Various Catalyst Used for Chalcone Synthesis, *Mini-Rev Org. Chem.*, 13, 87-94.
- DeVita, V.T., Oliverio, U.T., Muggia, F.M., Wiernik, P.W., Ziegler, J., Goldin, A., Rubin, D., Henney, J., and Schepartz, S., 1979, The Drug Development and Clinical Trials Programs of the Division of Cancer Treatment, National Cancer Institute, *Am. J. Clin. Oncol.*, 2, 195-216.
- Dumeignil, F., Paul, J.F., and Paul, S., 2017, Heterogeneous Catalyst with Renewed Attention: Principles, Theories, and Concepts, *J. Chem. Educ.*, 94, 675-689.
- Fearon, E.R., and Vogelstein, B., 1990, A Genetic Model for Colorectal Tumorigenesis, *Cell*, 61, 759-767.
- Fitzmaurice, C., Allen, C., Barber, R.M., *et al.*, 2017, Global, Regional, and National Cancer Incidence, Mortality, Years of Life Lost, Years Lived with Disability, and Disability-Adjusted Life-years for 32 Cancer Groups, 1990 to 2015: A Systematic Analysis for the Global Burden of Disease Study, *JAMA Oncol.*, 3, 524-548
- Freshney, R.I., 2005, *Culture of Animal Cells*, Wiley & Sons, Inc., New Jersey

- Gaonkar, S.L., and Vignesh, U.N., 2017, Synthesis and pharmacological properties of chalcones: a review, *Res. Chem. Intermed.*, 43, 6043-6077.
- Golubeva, O.Y., Korytkova, E.N., and Gusarov, V.V., 2005, Hydrothermal Synthesis of Magnesium Silicate Montmorillonite for Polymer-Clay Nanocomposites, *Russ. J. Appl. Chem.*, 1, 26-32.
- Hanauske, A.R., Ross, M., Degen, D., Hilsenbeck, S.G., and Von Hoff, D.D., 1993, In vitro of the benzotriazine dioxide SR 4233 against human tumor colony-forming units, *Eur. J. Cancer.*, 423-425.
- Handayani, S., Matsjeh, S., Anwar, C., Atun, S., and Fatimah, I., 2012, Novel synthesis of 1,5-dibenzalacetone using NaOH/ ZrO<sub>2</sub>-montmorillonite as cooperative catalyst, *Int. J. Chem. Anal. Sci.*, 3, 6-10.
- Handayani, S., Hermawan, A., Meiyanto, E., and Udin, Z., 2013, Induction of Apoptosis on MCF-7 cells by Selaginella Fractions, *J. Appl. Phar. Sci.*, 3, 31-34.
- Harmastuti, N., Herowati, R., Susilowati, D., Pranowo, H.D., and Mubarika, S., 2012, Synthesis and cytotoxic activity of chalcone derivatives on human breast cancer cell lines, *Indo. J. Chem.*, 12, 261-267.
- Karthikeyan, C., Moorthy, N.S., Ramasamy, S., Vanam, U., Manivannan, E., Karunakaran, D., and Trivedi, P., Advances in chalcones with anticancer activities, *Recent Pat Anti-Canc.*, 10, 97-115.
- Pawlak, A., Henklewska, M., Suárez, B.H., Łużny, M., Kozłowska, E., Mrukowicz, B.O., and Janeczko, T., 2020, Chalcone Methoxy Derivatives Exhibit Antiproliferative and Proapoptotic Activity on Canine Lymphoma and Leukemia Cells, *Molecules*, 25(4362), 1-15
- Higginson, J., Muir, C.S., and Muñoz, N., 1992, *Human cancer: epidemiology and environmental causes*, Cambridge University Press, New York.
- Hoeldrich, W.F., and Kollmer, F., 2000, Oxidation reactions in the synthesis of fine and intermediate chemicals using environmentally benign oxidants and the right reactor system, *Pure Appl. Chem.*, 72, 1273-1287.
- Hutabarat, Y.F., Synthesis of N-phenyl Pyrazoline Derivatives from Anise Seed Oil as Antimicrobial Candidates, *Undergraduate Thesis*, Chemistry Department FMIPA UGM, Yogyakarta.
- Jadidi, K., Gharemanzadeh, R., Mehrdad, M., Darabi, H.R., Khavasi, H.R., and Asgari, D., 2008, A Facile synthesis of novel pyrrolizidines under classical and ultrasound conditions, *Ultrason. Sonochem.*, 15, 124-128.
- Jayapal, M.R., Prasad, K.S., and Sreedhar, N.Y., 2010, Synthesis and characterization of 2,5-dihydroxy substituted chalcones using SOCl<sub>2</sub>/EtOH, *Int. J. Pharm. Pharm. Sci.*, 4, 361-366.

- Jiménez, G.I., Bravo, J.A., and Vila, J.L., 2016, Synthesis of benzylideneacetophenone under microwave irradiation; green chemistry, *Rev. Boliv. Quím.*, 33, 179-182.
- Joshi, A., Ramaswamy, A., Noronha, V., Patil, V.M., Chandrasekharan, A., Goel, A., Sahu., Sable, N., Agrawal, A., Menon, S., and Prabhash, K., 2016, Efficacy and safety of sorafenib in advanced renal cell cancer and validation of Heng criteria, *Indian J. Cancer*, 53, 423-428.
- Kalambe, N.A., Raghuwanshi, P.B., and Dhanbhar, H.R., 2014, Synthesis of 2-hydroxy substituted chalcone dibromide, *Int. J. Chem. Sci.*, 12, 260-264.
- Kaur, N., and Kishore, D., 2012, Montmorillonite: An efficient, heterogeneous and green catalyst for organic synthesis, *J. Chem. Pharm.*, 4, 991-1015.
- Li, J.T., Yang, W.Z., Wang, S.X., Li, S.H., Li, T.S., 2002, Improved synthesis of chalcones under ultrasound irradiation, *Ultrason Sonochem*, doi: 10.1016/s1350-4177(02)00079-2.
- Li, Y.P., Yang, Y.C., Li, Y.K., Jiang, Z.Y., Huang, X.Z., Wang, W.G., Gao, X. M., and Hu, Q. F., 2014, Prenylated chalcones from *Desmodium renifolium*, *Photochem. Lett.*, 9, 41-45.
- Lim, Y.H., Oo, C.W., Koh, R.Y., Voon, G.L., Yew, M.Y., Yam, M.F., and Loh, Y.C., 2020, Synthesis, characterization, and anti-cancer activity of new chalcone derivatives containing naphthalene and fluorine moieties, *Drug Dev. Res.*, 81, 994-1003.
- Lin, Y.M., Zhou, Y., Flavin, M.T., and Zhou, L.M., 2002, Chalcones and flavonoids as anti-Tuberculosis agents, *Bioorg. Med. Chem.*, 10, 2795-802.
- Liew, S.K., Malagobadan, S., Arshad, N.M., and Nagoor, N.H., 2020, A Review of the Structure-Activity Relationship of Natural and Synthetic Antimetastatic Compounds, *Biomolecules*, 10(138), 1-28
- Lopez, J., and Tait, S.W., 2015, Mitochondrial apoptosis: killing cancer using the enemy within. *Br. J. Cancer*, 112, 957-962.
- López, G., Mellado, M., Werner, E., Said, B., Godoy, P., Caro, N., Besoain, X., Montenegro, I., and Madrid, A., 2020, Sonochemical Synthesis of 2-Hydroxy-Chalcone Derivatives with potential Anti-Oomycete Activity, *Antibiotics*, 9(576), doi.org/10.3390/antibiotics9090576
- Maioral, M., Cristina, P., Souza, G.R.R., Mascarello, A., Chiaradia, L.D., Licínio, M.A., Moraes, A.C.R.D., Yunes, R., Nunes, R., and Santos-Silva, M.C., 2013, Apoptotic events induced by synthetic naphthylchalcones in human acute leukemia cell lines, *Biochimie*, 95, 866-874.
- Nugroho, A.E., Hermawan, A., Putri, D.D.P., Novika, A., Meiyanto, E., and Kawaichi, M., 2013, Combinational effects of hexane insoluble fraction of

- Ficus septica Burm. F. and doxorubicin chemotherapy on T47D breast cancer cells, *Asian Pac. J. Trop. Biomed.*, 3, 297-302.
- Mai, C.W., Yaeghoobi, M., Abd-Rahman, N., Kang, Y.B., Pichika, M.R., 2014, Chalcones with electron-withdrawing and electron-donating substituents: Anticancer activity against TRAIL resistant cancer cells, structure–activity relationship analysis and regulation of apoptotic proteins, *Eur J Med Chem*, 378-387.
- Miles, C.O., Main, L., and Nicholson, B.K., 1989, Synthesis of 2', 6'-dihydroxychalcones by using tetrahydropyran-2-yl and trialkylsilyl protective groups; the crystal structure determination of 2',6'-dihydroxy-2,4,6-trimethoxychalcone, *Aust. J. Chem.*, 42, 1103-1113.
- Mossman, T., 1983, Rapid colorimetric assay for cellular growth and survival: application to proliferation and cytotoxicity assays, *J. Immunol. Methods*, 65, 55-63.
- Nagendrappa, G., 2002, Organic synthesis using clay catalysts, *Reson. J. Sci. Educ.*, 7, 64-77.
- Nomura, H., and Koda, S., 2015, *What Is Sonochemistry? Sonochemistry and the Acoustic Bubble*, Elsevier, Cambridge.
- Ohkatsu, Y., and Satoh, T., 2007, Antioxidant and photo-antioxidant activities of chalcone derivatives, *J. Japan Pet. Inst.*, 51, 298-308.
- Patil, R., Bhoir, P., Deshpande, P., Wattamwar, T., Shirude, M., and Chaskar, P., 2013, Relevance of sonochemistry or ultrasound (US) as a proficient means for the synthesis of fused heterocycles, *Ultrason. Sonochem.*, 20, 1327-1336.
- Purnami, Wardana, I.N.G., dan Veronika. K., 2015, Pengaruh penggunaan katalis terhadap laju dan efisiensi pembentukan hidrogen, *Rekayasa Mesin*, 6, 51-59.
- Ramagathan, B., Gopiraman, M., Olasunkanmi, L.O., Kabanda, M.M., Yesudass, S., Bahadur, I., Adekunle, A. S., Obot, I.B., and Ebenso, E.E., 2015, Synthesized photo-cross-linking chalcones as novel corrosion inhibitors for mild steel in acidic medium: experimental, quantum chemical and Monte Carlo simulation studies, *RSC Adv.*, 5, 76675-76688.
- Reed, J. C., Jurgensemeier, J. M., and Matusayama, S., 1998, Bcl-2 family proteins and mitochondria, *Biochim. Biophys. Acta*, 1366, 127-137.
- Sang, Z., Wang, K., Zhang, P., Shi, J., Liu, W., and Tan, Z., 2019, Design, synthesis, in-silico and biological evaluation of novel chalcone derivatives as multi-function agents for the treatment of Alzheimer's disease, *Eur J Med Chem*, 238-252.

- Santos, P., Aguiar, A.C., Barbero, G.F., Rezende, C.A., and Martínez, J., 2015, Supercritical carbon dioxide extraction of capsaicinoids from malagueta pepper (*Capsicum frutescens* L.) assisted by ultrasound, *Ultrason. Sonochem.*, 22, 78-88.
- Schiel, M.A., Chopa, A.B., Silbestri, G.F., Alvarez, M.B., Lista, A.G., and Domini, C.E., 2015, *Green Synthetic Approaches for Biologically Relevant Heterocycles*, Elsevier. Cambridge.
- Sinha, S., Batovska, D.I., Medhi, B., Radotra, B.D., Bhalla, A., Markova, and Sehgal, R., 2019, *In vitro* anti-malarial efficacy of chalcones: cytotoxicity profile, mechanism of action and their effect on erythrocytes, *Malar J*, 18(421), doi.org/10.1186/s12936-019-3060-z
- Smith, G.V., Notheisz, F., 1999, *Heterogeneous Catalysis in Organic Chemistry*, Academic Press, Cambridge.
- Sreedhar, N.Y., Jayapal, M.R., Prasad, K.S., and Prasad, P.R., 2010, Synthesis and characterization of 4-hydroxy chalcones using PEG-400 as a recyclable solvent, *Res. J. Pharm.*, 1, 480-485.
- Suma, A.A.T., Wahyuningsih, T.D., and Mustofa, 2019, Efficient synthesis of choloro chalcones under ultrasound irradiation, their anticancer activities and molecular docking studies, *Rasayan J. Chem.*, 2, 502-510.
- Suslick, K.S., 2003, *Sonochemistry, in Comprehensive Coordination Chemistry (II ed)*, Oxford, Pergamon, 731-739.
- Syam, S., Abdelwahab, S.I., Al-Mamary, M.A., and Mohan, S., 2012, Synthesis of chalcones with anticancer activities, *Molecules*, 17, 6179-95.
- Tanamatarayat, P., Chunsakaow, S., and Duangrat, C., 2003, Screening of some rubiaceae plants for cytotoxicity activity against cervix carcinoma (KB-3-1) cell line, *J. Pharm. Sci.*, 27, 167-172.
- Tekale, S., Mashele, S., Pooe, O., Kendrekar, P., and Pawar, R., 2019, *Vector-Borne Diseases: Recent Developments in Epidemiology and Control*, Books and Demand, Norderstedt.
- Weyerman, J., Lochmann, D., and Zimmer, A., 2005, A practical note on the use of cytotoxicity assays, *Int. J. Pharm.*, 288, 396-76.
- Xu, X.D., Jiang, H.P., Cao, Y.W., Wang, Y.H., Yang, X.C., Wang, Y.L., Wang, X.S., and Niu, H.T., 2015, Warburg effect or reverse Warburg effect? A review of cancer metabolism, *Oncol. Res. Treat.*, 117-122.
- Murti, Y., Goswami, A., and Mishra, P., 2013, Synthesis and antioxidant activity of some chalcones and flavonoids, *Int. J. Pharmtech Sci. Res.*, 5, 811-818.



UNIVERSITAS  
GADJAH MADA

**Synthesis and cytotoxicity assay of chalcones from benzaldehydes and acetophenone derivatives as anticancer agent**

KENTYARTO ISNANDI, Dr. Winarto Haryadi, M.Si; Dr. Tutik Dwi Wahyuningsih, M.Si.

Universitas Gadjah Mada, 2021 | Diunduh dari <http://etd.repository.ugm.ac.id/>

Zarate, X., Schott, E., Escobar, C.A., Lopez-Castro, R., Echeverria, C., Alvarado-Soto, L., and Ramirez-Tagle, R., 2016, Interaction of chalcones with CT-DNA by spectrophotometric analysis and theoretical simulations, *Quím. Nova*, 914-918.