PENGARUH TEKNIK IRADIASI UV-C TERHADAP PENURUNAN KADAR PESTISIDA BUPROFEZIN PADA BEBERAPA JENIS SEDUHAN TEH (*Camellia sinensis*)

SKRIPSI

Diajukan untuk memenuhi salah satu syarat untuk memperoleh
gelar Sarjana Sains pada Program Studi Kimia

oleh

Dewi Yulina Nur Soleha

NIM 1900598

KELOMPOK BIDANG KAJIAN MAKANAN
PROGRAM STUDI KIMIA
FAKULTAS PENDIDIKAN MATEMATIKA DAN ILMU PENGETAHUAN ALAM
UNIVERSITAS PENDIDIKAN INDONESIA
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Oleh:

Dewi Yulina Nur Soleha

Sebuah skripsi yang diajukan untuk memenuhi salah satu syarat untuk memperoleh gelar Sarjana Sains (S.Si) pada Program Studi Kimia di Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam Universitas Pendidikan Indonesia

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LEMBAR PENGESAHAN

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Oleh:

Dewi Yulina Nur Soleha

NIM: 1900598

Disetujui oleh,

Pembimbing I,

Dra. Hj. Zackiyah, M.Si.

NIP. 195912291991012001

Pembimbing II,

Drs. Ali Kusrijadi, M.Si.

NIP.196706291992031001

Mengetahui,

Ketua Program Studi Kimia FPMIPA UPI

Prof. Riri Khoerunnisa, Ph.D.

NIP. 197806282001122001

PERNYATAAN

Dengan ini saya menyatakan bahwa skripsi dengan judul **"Pengaruh Teknik Iradiasi UV-C terhadap Penurunan Kadar Pestisida Buprofezin pada Beberapa Jenis Seduhan Teh (*Camellia sinensis*)"** beserta seluruh isinya adalah benar-benar karya saya sendiri. Saya tidak melakukan pengutipan atau penjiplakan dengan cara-cara yang tidak sesuai dengan etika keilmuan yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menerima risiko atau sanksi apabila kemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya.

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Yang membuat pernyataan,

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ABSTRAK

Buprofezin merupakan pestisida yang banyak digunakan untuk mengurangi hama tanaman teh. Penelitian sebelumnya menunjukkan bahwa residu buprofezin ditemukan dalam seduhan teh. Keberadaan residu buprofezin dapat berbahaya bagi kesehatan. Penelitian ini bertujuan mengkaji penurunan kadar buprofezin, aktivitas antioksidan dalam ketiga jenis seduhan teh (putih, hijau, dan hitam) dan konfirmasi hasil fotodegradasi buprofezin pada seduhan teh hijau akibat iradiasi UV-C. Penurunan residu buprofezin dalam berbagai sampel teh dan konfirmasi produk fotodegradasi dianalisis menggunakan instrumen LC-MS/MS *Triple Quadrupole* sedangkan penurunan aktivitas antioksidan menggunakan 2,2-difenil-1- pikrilhidrazil (DPPH). Hasil penelitian menunjukkan bahwa teknik iradiasi UV-C dapat menurunkan kadar buprofezin pada ketiga jenis seduhan teh tetapi tidak signifikan, yaitu 29,27% pada teh putih, 29,30% pada teh hijau, dan 31,81% pada teh hitam. Hasil penelitian juga menunjukkan bahwa iradiasi UV-C menurunkan aktivitas antioksidan pada ketiga jenis seduhan teh, dengan penurunan aktivitas antioksidan paling tinggi ada pada teh putih (15,11%), teh hijau (7,63%), dan paling rendah teh hitam (6,70%). Terkonfirmasi tiga produk senyawa hasil fotodegradasi buprofezin pada jenis seduhan teh hijau yaitu 1-(ters-butil)-3-isopropiltiourea, 1-(ters-butil)-3-metilkarbamoil-isopropiltiourea dan 1-isopropil-3-fenilurea. Hasil ini mengkonfirmasi bahwa kandungan senyawa dalam ketiga jenis teh dikonfirmasi dari aktivitas antioksidan yang menurun menujukkan efek penghambatan degradasi buprofezin, dengan kemampuan penghambatan degradasi buprofezin tertinggi ada pada jenis teh putih.

Kata kunci: aktivitas antioksidan, buprofezin, fotodegradasi, jenis teh, LC-MS/MS

ABSTRACT

Buprofezin is a pesticide that is widely used to reduce tea plant pests. Previous studies have shown that buprofezin residues are found in tea infusion. The presence of buprofezin residues can be hazardous to health. This study aims to examine the decrease in buprofezin levels, antioxidant activity in the three types of tea infusions (white, green and black) and to confirm the results of photodegradation of buprofezin in infusions of green tea due to UV-C irradiation. The reduction of buprofezin residues in various tea samples and confirmation of product photodegradation were analyzed using the LC-MS/MS Triple Quadrupole instrument while the decrease in antioxidant activity used 2,2-diphenyl-1-picrylhydrazyl (DPPH). The results showed that the UV-C irradiation technique reduced buprofezin levels in the three types of tea infusion but not significantly, namely 29.27% for white tea, 29.30% for green tea, and 31.81% for black tea. The research results also showed that UV-C irradiation reduced antioxidant activity in the three types of tea infusion, with the highest reduction in antioxidant activity in white tea (15.11%), green tea (7.63%), and the lowest in black tea (6.70%). It was confirmed that 3 products resulted from the photodegradation of buprofezin in green tea infusion, namely 1-(tert-butyl)-3-isopropylthiourea, 1-(tert-butyl)-3-methylcarbamoyl-isopropylthiourea and 1-isopropyl-3-phenylurea. These results confirm that the compound content in the three types of tea is confirmed by the decreased antioxidant activity showing an inhibitory effect on buprofezin degradation, with the highest ability to inhibit buprofezin degradation in the white tea type.

Keywords: antioxidant activity, buprofezin, photodegradation, tea matrix, LC-MS/MS

DAFTAR ISI

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DAFTAR GAMBAR

DAFTAR LAMPIRAN

DAFTAR PUSTAKA

Afzal, M., Safer, A. M., & Menon, M. (2015). Green tea polyphenols and their potential role in health and disease. *Inflammopharmacology*, *23*(4), 151–161. https://doi.org/10.1007/s10787-015-0236-1

AlMulla, S. A. M. (2016). Determination of multiple pesticides residues in imported tea in UAE using liquid and gas chromatography and tandem mass spectrometry. *Electronic Theses and Dissertations*, 1–198.

Anggraini, T. (2018). Proses dan Manfaat Teh. In *Journal of Chemical Information and Modeling* (Vol. 53, Issue 9).

Antari, N, M, R, O., Wartini, N, M., & Mulyani, S. (2015). Pengaruh Ukuran Partikel dan Lama Ekstraksi Terhadap Karakteristik Ekstrak Warna Alami Buah Pandan (Pandanus tectorius). *Jurnal Rekayasa Dan Manajemen Agroindustri*, *3*(4), 30–40.

Ariani, N. L. K., Suaniti, N. M., & Sibarani, J. (2015). Tinggi Eluasi Gradien Dengan Isokratik Pada Penentuan Vitamin B1 , B2 Dan B6 Dalam Sediaan Sirup. *Cakra Kimia*, *3*(12), 1–8.

Armoskaite, V., Ramanauskiene, K., Maruska, A., Razukas, A., Dagilyte, A., Baranauskas, A., & Briedis, V. (2011). The analysis of quality and antioxidant activity of green tea extracts. *Journal of Medicinal Plants Research*, *5*(5), 811–816.

Aryanti, R., Perdana, F., & Syamsudin, R. A. M. R. (2021). Telaah Metode Pengujian Aktivitas Antioksidan pada Teh Hijau (Camellia sinensis (L.) Kuntze). *Jurnal Surya Medika*, *7*(1), 15–24. https://doi.org/10.33084/jsm.v7i1.2024

Astill, C., Birch, M. R., Dacombe, C., Humphrey, P. G., & Martin, P. T. (2001). Factors affecting the caffeine and polyphenol contents of black and green tea infusions. *Journal of Agricultural and Food Chemistry*, *49*(11), 5340–5347. https://doi.org/10.1021/jf010759+

Bai, A., Chen, A., Chen, W., Liu, S., Luo, X., Liu, Y., & Zhang, D. (2021). Residue behavior, transfer and risk assessment of tolfenpyrad, dinotefuran and its metabolites during tea growing and tea brewing. *Journal of the Science of*

Food and Agriculture, *101*(14), 5992–6000. https://doi.org/10.1002/jsfa.11253

Baijuan, W., & Zhang, G. (2021). *Meminum dan Mencicipi Teh Yunnan Pu'er / Wang Baijuan* (Pertama). PT Pustaka Obor Indonesia.

Bibi, R., & Qureshi, I. Z. (2019). Short-term exposure of Balb/c mice to buprofezin insecticide induces biochemical, enzymatic, histopathologic and genotoxic damage in liver and kidney tissues. *Toxicology Mechanisms and Methods*, *29*(8), 587–603. https://doi.org/10.1080/15376516.2019.1631924

Bintsis, T., Litopoulou-Tzanetaki, E., & Robinson, R. . (2000). Existing and potential applications of ultraviolet light in the food industry – a critical review. *Journal of the Science of Food and Agriculture*, *80*(6), 637–645. https://doi.org/(SICI)1097-0010(20000501)80_6_637__AID-JSFA603_3.0.CO

Budiyanto, A. K. (2018). *Membuat Fungisida Organik*. UMM Press.

Burrows, H. D., Canle L, M., Santaballa, J. A., & Steenken, S. (2002). Reaction pathways and mechanisms of photodegradation of pesticides. *Journal of Photochemistry and Photobiology B: Biology*, *67*(2), 71–108. https://doi.org/10.1016/S1011-1344(02)00277-4

Carloni, P., Tiano, L., Padella, L., Bacchetti, T., Customu, C., Kay, A., & Damiani, E. (2013). Antioxidant activity of white, green and black tea obtained from the same tea cultivar. *Food Research International*, *53*(2), 900–908. https://doi.org/10.1016/j.foodres.2012.07.057

Castiglioni, S., Damiani, E., Astolfi, P., & Carloni, P. (2015). Influence of steeping conditions (time, temperature, and particle size) on antioxidant properties and sensory attributes of some white and green teas. *International Journal of Food Sciences and Nutrition*, *66*(5), 491–497. https://doi.org/10.3109/09637486.2015.1042842

Chandra, S., Patras, A., Pokharel, B., Bansode, R. R., Begum, A., & Sasges, M. (2017). Patulin degradation and cytotoxicity evaluation of UV irradiated apple juice using human peripheral blood mononuclear cells. *Journal of Food Process Engineering*, *40*(6), 1–9. https://doi.org/10.1111/jfpe.12586

Chen, C.-W.-W., & Ho, C. -T. (1995). Antioxidant Properties of Polyphenols

Extracted From Green and Black Teas. *Journal of Food Lipids*, *2*(1), 35–46. https://doi.org/10.1111/j.1745-4522.1995.tb00028.x

Chen, H., Gao, G., Chai, Y., Ma, G., Hao, Z., Wang, C., Liu, X., & Lu, C. (2017). Multiresidue Method for the Rapid Determination of Pesticide Residues in Tea Using Ultra Performance Liquid Chromatography Orbitrap High Resolution Mass Spectrometry and In-Syringe Dispersive Solid Phase Extraction. *ACS Omega*, *2*(9), 5917–5927. https://doi.org/10.1021/acsomega.7b00863

Chen, H., Pan, M., Liu, X., & Lu, C. (2017). Evaluation of transfer rates of multiple pesticides from green tea into infusion using water as pressurized liquid extraction solvent and ultra-performance liquid chromatography tandem mass spectrometry. *Food Chemistry*, *216*, 1–9. https://doi.org/10.1016/j.foodchem.2016.07.175

Chen, H., Pan, M., Pan, R., Zhang, M., Liu, X., & Lu, C. (2015). Transfer rates of 19 typical pesticides and the relationship with their physicochemical property. *Journal of Agricultural and Food Chemistry*, *63*(2), 723–730. https://doi.org/10.1021/jf506103d

Chen, H., Wang, Q., Jiang, Y., Wang, C., Yin, P., Liu, X., & Lu, C. (2015). Monitoring and risk assessment of 74 pesticide residues in Pu-erh tea produced in Yunnan, China. *Food Additives and Contaminants: Part B Surveillance*, *8*(1), 56–62. https://doi.org/10.1080/19393210.2014.972471

Chen, Q., Shi, J., Mu, B., Chen, Z., Dai, W., & Lin, Z. (2020). Metabolomics combined with proteomics provides a novel interpretation of the changes in nonvolatile compounds during white tea processing. *Food Chemistry*, *332*, 127412. https://doi.org/10.1016/j.foodchem.2020.127412

Chen, S. X., Luo, J. L., Li, P. W., Zhang, X., Ao, C. W., & Li, J. H. (2020). Study on the Effect of Cleaning Technology of Fresh Tea Leaves on the Quality of Green Tea. *Materials Science Forum*, *984*, 160–167. https://doi.org/10.4028/www.scientific.net/msf.984.160

Chen, Z., & Lin, Z. (2015). Tea and human health: biomedical functions of tea active components and current issues. *Journal of Zhejiang University: Science B, 16*(2), 87–102. https://doi.org/10.1631/jzus.B1500001

Cossu, A., Huang, K., Cossu, M., Tikekar, R. V., & Nitin, N. (2018). Fog, phenolic

acids and UV-A light irradiation: A new antimicrobial treatment for decontamination of fresh produce. *Food Microbiology*, *76*(January), 204–208. https://doi.org/10.1016/j.fm.2018.05.013

Cottin, H., Kotler, J. M., Billi, D., Cockell, C., Demets, R., Ehrenfreund, P., Elsaesser, A., d'Hendecourt, L., van Loon, J. J. W. A., Martins, Z., Onofri, S., Quinn, R. C., Rabbow, E., Rettberg, P., Ricco, A. J., Slenzka, K., delaTorre, R., de Vera, J. P., Westall, F., … Klamm, B. A. (2017). Space as a Tool for Astrobiology: Review and Recommendations for Experimentations in Earth Orbit and Beyond. In *Space Science Reviews* (Vol. 209, Issues 1–4). The Author(s). https://doi.org/10.1007/s11214-017-0365-5

Dai, J., Jiang, C., Chai, Y., Wang, C., Chen, H., & Liu, X. (2021). Photolysis kinetics of cartap and nereistoxin in water and tea beverages under irradiation of simulated sunlight and ultraviolet under laboratory conditions. *Food Chemistry*, *355*(October 2020), 129595. https://doi.org/10.1016/j.foodchem.2021.129595

Datta, S., & Walia, S. (1997). Photodegradation of buprofezin. *Toxicological and Environmental Chemistry*, *60*(1–4), 1–11. https://doi.org/10.1080/02772249709358446

Deb, S., & Jolvis Pou, K. R. (2016). A Review of Withering in the Processing of Black Tea. *Journal of Biosystems Engineering*, *41*(4), 365–372. https://doi.org/10.5307/jbe.2016.41.4.365

Diffey, B. L. (2002). Sources and measurement of ultraviolet radiation. *Methods*, *28*(1), 4–13. https://doi.org/10.1016/S1046-2023(02)00204-9

Djordjevic, T., & Djurovic-Pejcev, R. (2016). Food processing as a means for pesticide residue dissipation. *Pesticidi i Fitomedicina*, *31*(3–4), 89–105. https://doi.org/10.2298/pif1604089d

Effendi, D. ., Syakir, M., Yusron, M., & Wiratno. (2010). *Budidaya dan Pasca Panen Teh*. Pusat Penelitian dan Pengembangan Perkebunan. Departemen Pertanian Republik Indonesia.

European Commission Regulation (EU). (2019). *European Parliament and of the Council as regards maximum residue levels for buprofezin, diflubenzuron, ethoxysulfuron, ioxynil, molinate, picoxystrobin and tepraloxydim in or on*

certain products. Journal of the European Union. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0091&from=SV

Food and Drug Administration. (2000). Irradiation in the Production, Processing and Handling of Food. *Federal Register*, *65*(230), 71056–71058. https://doi.org/10.1016/0196-335x(80)90058-8

Gao, W., Yan, M., Xiao, Y., Lv, Y., Peng, C., Wan, X., & Hou, R. (2019). Rinsing Tea before Brewing Decreases Pesticide Residues in Tea Infusion. *Journal of Agricultural and Food Chemistry*, *67*(19), 5384–5393. https://doi.org/10.1021/acs.jafc.8b04908

Graham, H. N. (1992). Green tea composition, consumption, and polyphenol chemistry. *Preventive Medicine*, *21*(3), 334–350. https://doi.org/10.1016/0091-7435(92)90041-F

Grimalt, S., Pozo, Ó. J., Sancho, J. V., & Hernández, F. (2007). Use of liquid chromatography coupled to quadrupole time-of-flight mass spectrometry to investigate pesticide residues in fruits. *Analytical Chemistry*, *79*(7), 2833–2843. https://doi.org/10.1021/ac061233x

Gupta, R. C., & Milatovic, D. (2014). Insecticides. In *Biomarkers in Toxicology* (pp. 389–407). Academic press. https://doi.org/10.1016/B978-0-12-404630-6.00023-3

Hanani, E., Munim, A., & Sekarini, R. (2005). Identifikasi Senyawa Antioksidan Dalam Spons Callyspongia Sp Dari Kepulauan Seribu. *Majalah Ilmu Kefarmasian*, *2*(3), 127–133. https://doi.org/10.7454/psr.v2i3.3389

Harmita. (2004). Petunjuk Pelaksanaan Validasi dan Cara Penggunaannya. *Majalah Ilmu Kefarmasian*, *1*(3), 117.

Harmita, K., Harahap, Y., & Supandi. (2019). *Liquid Chromatography-Tandem Mass Spectrometry (LC-MS/MS)*. PT.ISFI Penerbitan.

He, J., Evans, N. M., Liu, H., Zhu, Y., Zhou, T., & Shao, S. (2021). UV treatment for degradation of chemical contaminants in food: A review. *Comprehensive Reviews in Food Science and Food Safety*, *20*(2), 1857–1886. https://doi.org/10.1111/1541-4337.12698

Heshmati, A., Mehri, F., & Khaneghah, A. M. (2020). Simultaneous multi-

determination of pesticide residues in black tea leaves and infusion: A risk assessment study. *Environmental Science and Pollution Research*, 1–11. https://doi.org/10.1007/s11356-020-11658-3

Hilal, Y., & Engelhardt, U. (2007). Characterisation of white tea - Comparison to green and black tea. *Journal Fur Verbraucherschutz Und Lebensmittelsicherheit*, *2*(4), 414–421. https://doi.org/10.1007/s00003-007-0250-3

Holt, J. S. (2013). Herbicides. In *Encyclopedia of Biodiversity (Second Edition)* (Vol. 4, Issue 1974, pp. 87–95). Elsevier Science. https://doi.org/10.1016/B978-0-12-384719-5.00070-8

Huang, Y., Shi, T., Luo, X., Xiong, H., Min, F., Chen, Y., Nie, S., & Xie, M. (2019). Determination of multi-pesticide residues in green tea with a modified QuEChERS protocol coupled to HPLC-MS/MS. *Food Chemistry*, *275*, 255–264. https://doi.org/10.1016/j.foodchem.2018.09.094

Huang, Z., Zhang, Y., Wang, L., Ding, L., Wang, M., Yan, H., Li, Y., & Zhu, S. (2009). Simultaneous determination of 103 pesticide residues in tea samples by LC-MS/MS. *Journal of Separation Science*, *32*(9), 1294–1301. https://doi.org/10.1002/jssc.200800605

Hudayya, A., & Jayanti, H. (2013). *Pengelompokan Pestisida Berdasarkan Cara Kerja (Mode Of Action)*. Balai Penelitian Tanaman Sayuran.

Jansen, R., Lachatre, G., & Marquet, P. (2005). LC-MS/MS systematic toxicological analysis: Comparison of MS/MS spectra obtained with different instruments and settings. *Clinical Biochemistry*, *38*(4), 362–372. https://doi.org/10.1016/j.clinbiochem.2004.11.003

Jiang, Y., Jiang, Z., Ma, L., & Huang, Q. (2021). Advances in nanodelivery of green tea catechins to enhance the anticancer activity. *Molecules*, *26*(11). https://doi.org/10.3390/molecules26113301

Karlsson, R. (1973). Solubility of water in benzene derivatives. *Journal of Chemical and Engineering Data*, *18*(3), 290–292.

Karori, S. M., Wachira, F. N., Wanyoko, J. K., & Ngure, R. M. (2007). Antioxidant capacity of different types of tea products. *African Journal of Biotechnology*, *6*(19), 2287–2296. https://doi.org/10.5897/AJB2007.000-2358

Khokhar, S., & Magnusdottir, S. G. M. (2002). Total phenol, catechin, and caffeine contents of teas commonly consumed in the United Kingdom. *Journal of Agricultural and Food Chemistry*, *50*(3), 565–570. https://doi.org/10.1021/jf010153l

Kochman, J., Jakubczyk, K., Antoniewicz, J., Mruk, H., & Janda, K. (2020). Health Benefits and Chemical Composition of Matcha Green Tea: A Review. *Molecules (Basel, Switzerland)*, *26*(1). https://doi.org/10.3390/molecules26010085

Leonardo, F., Taufik, N. I., & Rinawati, D. (2019). Analisa Karakteristik Peminum Teh di Kota Bandung. *Jurnal Akuntansi Maranatha*, *11*(1), 77–97. http://journal.maranatha.edu

Leung, L. K., Su, Y., Chen, R., Zhang, Z., Huang, Y., & Chen, Z. Y. (2001). Theaflavins in black tea and catechins in green tea are equally effective antioxidants. *Journal of Nutrition*, *131*(9), 2248–2251. https://doi.org/10.1093/jn/131.9.2248

Li, C. H., Yang, Y. C., Wu, J. S., Huang, Y. H., Lee, C. T., Lu, F. H., & Chang, C. J. (2014). Increased tea consumption is associated with decreased arterial stiffness in a Chinese population. *PLoS ONE*, *9*(1), 3–8. https://doi.org/10.1371/journal.pone.0086022

Liao, C., Liu, X., Gao, A., Zhao, A., Hu, J., & Li, B. (2016). Maintaining postharvest qualities of three leaf vegetables to enhance their shelf lives by multiple ultraviolet-C treatment. *Lwt*, *73*, 1–5. https://doi.org/10.1016/j.lwt.2016.05.029

Lin, T., Chen, X. L., Guo, J., Li, M. X., Tang, Y. F., Li, M. X., Li, Y. G., Cheng, L., & Liu, H. C. (2022). Simultaneous Determination and Health Risk Assessment of Four High Detection Rate Pesticide Residues in Pu'er Tea from Yunnan, China. *Molecules*, *27*(3), 1–15. https://doi.org/10.3390/molecules27031053

Liu, Y. (2021). Analysis of the Effective Ingredients in Tea. *Proceedings of the 7th International Conference on Humanities and Social Science Research (ICHSSR 2021)*, *554*, 696–699. https://doi.org/10.2991/assehr.k.210519.138

Łozowicka, B., & Jankowska, M. (2016). Comparison of the effects of water and

thermal processing on pesticide removal in selected fruit and vegetables. *Journal of Elementology*, *21*(1), 99–111. https://doi.org/10.5601/jelem.2015.20.2.917

Lozowicka, B., Jankowska, M., Hrynko, I., & Kaczynski, P. (2016). Removal of 16 pesticide residues from strawberries by washing with tap and ozone water, ultrasonic cleaning and boiling. *Environmental Monitoring and Assessment*, *188*(1), 1–19. https://doi.org/10.1007/s10661-015-4850-6

Lu, J., Zhang, Z., Lin, X., Chen, Z., Li, B., & Zhang, Y. (2022). Removal of imidacloprid and acetamiprid in tea (Camellia sinensis) infusion by activated carbon and determination by HPLC. *Food Control*, *131*(June 2021). https://doi.org/10.1016/j.foodcont.2021.108395

Majumder, S., Mandal, S., Majumder, B., Paul, A., Paul, T., Sahana, N., & Mondal, P. (2022). A liquid chromatographic method for determination of acetamiprid and buprofezin residues and their dissipation kinetics in paddy matrices and soil. *Environmental Science and Pollution Research*, *29*(1), 1401–1412. https://doi.org/10.1007/s11356-021-15784-4

Masike, K., & Madala, N. (2018). Synchronized Survey Scan Approach Allows for Efficient Discrimination of Isomeric and Isobaric Compounds during LC-MS / MS Analyses. *Journal of Analytical Methods in Chemistry*, 1–8. https://doi.org/10.1155/2018/2046709

Miean, K. H., & Mohamed, S. (2001). Flavonoid (Myricetin, Quercetin, Kaempferol, Luteolin, and Apigenin) Content of Edible Tropical Plants. *Journal of Agricultural and Food Chemistry*, *49*, 3106–3112.

Mihelj, T., Belščak-Cvitanović, A., Komes, D., Horžić, D., & Tomašić, V. (2014). Bioactive compounds and antioxidant capacity of yellow Yinzhen tea affected by different extraction conditions. *Journal of Food and Nutrition Research*, *53*(3), 278–290.

Miller, T. A. (1988). Mechanisms of resistance to pyrethroid insecticides. *Parasitology Today*, *4*(7), S8–S12. https://doi.org/10.1016/0169-4758(88)90080-4

Monitria, M., & Indirawati, S. M. (2021). Analisis Kadar Residu Pestisida Sebelum dan Sesudah Perlakuan Pencucian Menggunakan Citrus Aurantifoliia pada

Lactuca Sativa L. *JUMANTIK (Jurnal Ilmiah Penelitian Kesehatan)*, *6*(2), 185. https://doi.org/10.30829/jumantik.v6i2.8103

Mu, H., Yang, X., Wang, K., Tang, D., Xu, W., Liu, X., Ritsema, C. J., & Geissen, V. (2023). Ecological risk assessment of pesticides on soil biota: An integrated field-modelling approach. *Chemosphere*, *326*(December 2022), 138428. https://doi.org/10.1016/j.chemosphere.2023.138428

Munteanu, I. G., & Apetrei, C. (2022). Assessment of the Antioxidant Activity of Catechin in Nutraceuticals : Comparison between a Newly Developed Electrochemical Method and Spectrophotometric Methods. *International Journal of Molecular Sciences*, *23*(15), 1–29.

Mutmainnah, N., Chadijah, S., & Qaddafi, M. (2018). Penentuan Suhu Dan Waktu Optimum Penyeduhan Batang Teh Hijau (Camelia Sinensis L.) Terhadap Kandungan Antioksidan Kafein, Tanin Dan Katekin. *Lantanida Journal*, *6*(1), 1–102.

Nahim-Granados, S., Rivas-Ibáñez, G., Antonio Sánchez Pérez, J., Oller, I., Malato, S., & Polo-López, M. I. (2020). Fresh-cut wastewater reclamation: Techno-Economical assessment of solar driven processes at pilot plant scale. *Applied Catalysis B: Environmental*, *278*. https://doi.org/10.1016/j.apcatb.2020.119334

Nareshkumar, B., Sangnalmath, P. U., Gayatridevi, S., & Sreeramulu, K. (2018). A simple method for the separation and detection of trace levels of buprofezin, flubendiamide and imidacloprid by NP-HPTLC and RP-HPTLC. *Current Science*, *115*(5), 895–903. https://doi.org/10.18520/cs/v115/i5/895-903

Narukawa, M., Kimata, H., Noga, C., & Watanabe, T. (2010). Taste characterisation of green tea catechins. *International Journal of Food Science and Technology*, *45*(8), 1579–1585. https://doi.org/10.1111/j.1365-2621.2010.02304.x

Nielsen. (2018). *Riuh Rendah Kompetisi Pelepas Dahaga*. https://www.nielsen.com/insights/2018/riuh-rendah-kompetisi-pelepas-dahaga/

Nieto, L. M., Hodaifa, G., & Casanova, M. S. (2009). Elimination of pesticide residues from virgin olive oil by ultraviolet light: Preliminary results. *Journal*

of Hazardous Materials, *168*(1), 555–559. https://doi.org/10.1016/j.jhazmat.2009.02.030

Nugraha, A., Sumarwan, U., & Simanjuntak, M. (2017). Faktor determinan preferensi dan perilaku konsumsi teh hitam dan hijau. *Jurnal Manajemen & Agribisnis*, *14*(3), 198–208. https://doi.org/http://dx.doi.org/10.17358/jma.14.3.198

Nuro, A. (2018). *Organochlorine*. IntechOpen. https://doi.org/10.5772/intechopen.81271

Östman, M. (2018). *Antimicrobials in sewage treatment plants* (Issue October) [UMEA UNIVERSITY]. https://doi.org/10.13140/RG.2.2.30958.87367

Papoutsis, K., Vuong, Q. V., Pristijono, P., Golding, J. B., Bowyer, M. C., Scarlett, C. J., & Stathopoulos, C. E. (2016). Enhancing the total phenolic content and antioxidants of lemon pomace aqueous extracts by applying uv-c irradiation to the dried powder. *Foods*, *5*(3), 1–10. https://doi.org/10.3390/foods5030055

Pereira, V. P., Knor, F. J., Vellosa, J. C. R., & Beltrame, F. L. (2014). Determinação de compostos fenólicos e atividade antioxidante dos chás, verde, preto, e branco, de Camellia sinensis (L.) Kuntze, Theaceae. *Revista Brasileira de Plantas Medicinais*, *16*(3), 490–498.

Phaniendra, A., Jestadi, D. B., & Periyasamy, L. (2015). Free Radicals: Properties, Sources, Targets, and Their Implication in Various Diseases. *Indian Journal of Clinical Biochemistry*, *30*(1), 11–26. https://doi.org/10.1007/s12291-014-0446-0

Pinna, M. V., & Pusino, A. (2012). Direct and indirect photolysis of two quinolinecarboxylic herbicides in aqueous systems. *Chemosphere*, *86*(6), 655–658. https://doi.org/10.1016/j.chemosphere.2011.11.016

Prasetya, I. G. N. J. ., Widjaja, I. N. ., Nachia, S. ., Suryani, N. K. ., Putra, I. M. ., & Wirasuta, I. M. A. . (2016). Perubahan Aktivitas Mengkelat Logam Ekstrak Etanol Ubi Jalar Ungu terhadap Pengaruh Sinar UV-B. *Jurnal Farmasi Udayana*, *5*(2), 49–52.

Qureshi, I. Z., Bibi, A., Shahid, S., & Ghazanfar, M. (2016). Exposure to sub-acute doses of fipronil and buprofezin in combination or alone induces biochemical, hematological, histopathological and genotoxic damage in common carp

(Cyprinus carpio L.). In *Aquatic Toxicology* (Vol. 179). Elsevier B.V. https://doi.org/10.1016/j.aquatox.2016.08.012

Raeni, S. F., Haresmawati, U., Mulyasuryani, A., & Sabarudin, A. (2018). Evaluasi Pemisahan Alkilbenzena Menggunakan Kolom Monolith Berbasis Polimer Organik secara Kromatografi Cair Kinerja Tinggi. *ALCHEMY Jurnal Penelitian Kimia*, *14*(1), 37. https://doi.org/10.20961/alchemy.14.1.11266.37-50

Rahayu, R. S., Suprihatin, I. E., & Rita, W. S. (2017). Identifikasi Pewarna Merah K3 (Ci 15585) Dalam Produk Kosmetik Sediaan Perona Mata Secara Lc-Ms/Ms. *CAKRA KIMIA (Indonesian E-Journal of Applied Chemistry)*, *5*(1), 34. https://doi.org/10.24843/ck.2017.v05.i01.p05

Re, R., Nicoletta, P., Anna, P., Ananth, P., Min, Y., & Catherine, R.-E. (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, *26*((9-10)), 1231–1237.

Ren, Y., He, X., Yang, Y., Cao, Y., Li, Q., Peng, L., & Zou, L. (2022). Mitochondria-Mediated Apoptosis and Autophagy Participate in Buprofezin-Induced Toxic Effects in Non-Target A549 Cells. *Toxics*, *10*, 1–16. https://doi.org/https://doi.org/10.3390/toxics10100551

Sami, F. J., & Rahimah, S. (2016). Uji Aktivitas Antioksidan Ekstrak Metanol Bunga Brokoli (Brassica Oleracea L. Var. Italica) Dengan Metode DPPH (2,2 Diphenyl-1-Picrylhydrazyl) Dan Metode ABTS (2,2 azinobis (3-etilbenzotiazolin)-6-asam sulfonat). *Jurnal Fitofarmaka Indonesia*, *2*(2), 107–110. https://doi.org/10.33096/jffi.v2i2.179

Sheibani, E., Duncan, S. E., Kuhn, D. D., Dietrich, A. M., Newkirk, J. J., & O'Keefe, S. F. (2016). Changes in flavor volatile composition of oolong tea after panning during tea processing. *Food Science and Nutrition*, *4*(3), 456–468. https://doi.org/10.1002/fsn3.307

Shi, M., Nie, Y., Zheng, X. Q., Lu, J. L., Liang, Y. R., & Ye, J. H. (2016). Ultraviolet B (UVB) photosensitivities of tea catechins and the relevant chemical conversions. *Molecules*, *21*(10). https://doi.org/10.3390/molecules21101345

Singh, P. K., Singh, R. P., Singh, P., & Singh, R. L. (2019). Food hazards: Physical,

chemical, and biological. In *Food Safety and Human Health* (pp. 15–65). Elsevier Inc. https://doi.org/10.1016/B978-0-12-816333-7.00002-3

Singh, S., & Nelapati, K. (2017). Effect of food processing on degradation of hexachlorocyclohexane and its isomers in milk. *Veterinary World*, *10*(3), 270–275. https://doi.org/10.14202/vetworld.2017.270-275

Sitorus, F. C., Filzah, M., Naibaho, E. D., Siadari, F. A., Siregar, F. I., Damanik, T. H., Tambak, D. G. P., & Simalungun, U. (2023). Dampak usaha teh juma terhadap perkembangan ekonomi masyarakat sarimatondang. *Jurnal Penelitian Manajemen Dan Bisnis (JEKOMBIS)*, *2*(3), 65–75. https://doi.org/https://doi.org/10.55606/jekombis.v2i2

Słowik-Borowiec, M., & Szpyrka, E. (2020). Selected food processing techniques as a factor for pesticide residue removal in apple fruit. *Environmental Science and Pollution Research*, *27*(2), 2361–2373. https://doi.org/10.1007/s11356-019-06943-9

Srinivasan, D., Parkin, K., & Fennema, O. (2008). *Fennema's Food Chemistry-CRC Press (2008) - 4th Edition*.

Sugiyono. (2007). *Statistika Untuk Penelitian*. CV Alfabeta.

Suhartati, T. (2017). *Dasar-Dasar Spektrofotometri UV-Vis Dan Spektrometri Massa Untuk Penentuan Struktur Senyawa Organik*. CV. Anurgrah Utama Raharja.

Swami, S., Kumar, B., & Singh, S. B. (2021). Effect of ozone application on the removal of pesticides from grapes and green bell peppers and changes in their nutraceutical quality. *Journal of Environmental Science and Health - Part B Pesticides, Food Contaminants, and Agricultural Wastes*, *56*(8), 722–730. https://doi.org/10.1080/03601234.2021.1940660

Taheri, M., Giahi, M., Shahmohamadi, R., Ghafoori, H., Aghamaali, M. R., & Sariri, R. (2011). Screening antioxidant activity of extracts from different tea samples. *Pharmacologyonline*, *3*(January), 442–448.

Theppakorn, T. (2016). Stability and chemical changes of phenolic compounds during Oolong tea processing. *International Food Research Journal*, *23*(2), 564–574.

Tikekar, R. V., Anantheswaran, R. C., & Laborde, L. F. (2014). Patulin degradation

in a model apple juice system and in apple juice during ultraviolet processing. *Journal of Food Processing and Preservation*, *38*(3), 924–934. https://doi.org/10.1111/jfpp.12047

Tulandi, G. P., Sudewi, S., & Lolo, W. A. (2015). Validasi Metode Analisis Untuk Penetapan Kadar Parasetamol dalam Sediaan Tablet. *Pharmacon*, *4*(4), 168–178.

Vuong, Q. V., Golding, J. B., Stathopoulos, C. E., Nguyen, M. H., & Roach, P. D. (2011). Optimizing conditions for the extraction of catechins from green tea using hot water. *Journal of Separation Science*, *34*(21), 3099–3106. https://doi.org/10.1002/jssc.201000863

Wang, K., Liu, F., Liu, Z., Huang, J., Xu, Z., Li, Y., Chen, J., Gong, Y., & Yang, X. (2010). Analysis of chemical components in oolong tea in relation to perceived quality. *International Journal of Food Science and Technology*, *45*(5), 913–920. https://doi.org/10.1111/j.1365-2621.2010.02224.x

Wang, X., Zhou, L., Zhang, X., Luo, F., & Chen, Z. (2019). Transfer of pesticide residue during tea brewing: Understanding the effects of pesticide's physico-chemical parameters on its transfer behavior. *Food Research International*, *121*, 776–784. https://doi.org/10.1016/j.foodres.2018.12.060

Wei, Q., Mu, X. C., Yu, H. Y., Niu, C. D., Wang, L. X., Zheng, C., Chen, Z., & Gao, C. F. (2017). Susceptibility of Empoasca vitis (Hemiptera: Cicadellidae) populations from the main tea-growing regions of China to thirteen insecticides. *Crop Protection*, *96*, 204–210. https://doi.org/10.1016/j.cropro.2017.02.021

Widihati, I. A. G., Diantariani, N. P., & Yuliana, N. F. (2011). Fotodegradasi Metilen Biru Dengan Sinar UV Dan Katalis Al2O3. *Jurnal Kimia*, *1*, 31–42.

Wong, M., Sirisena, S., & Ng, K. (2022). Phytochemical profile of differently processed tea: A review. *Journal of Food Science*, *87*(5), 1925–1942. https://doi.org/10.1111/1750-3841.16137

Xu, Y. Q., Liu, P. P., Shi, J., Gao, Y., Wang, Q. S., & Yin, J. F. (2018). Quality development and main chemical components of Tieguanyin oolong teas processed from different parts of fresh shoots. *Food Chemistry*, *249*, 176–183. https://doi.org/10.1016/j.foodchem.2018.01.019

Yang, J., Song, L., Pan, C., Han, Y., & Kang, L. (2022). Removal of ten pesticide residues on/in kumquat by washing with alkaline electrolysed water. *International Journal of Environmental Analytical Chemistry*, *102*(15), 3638–3651. https://doi.org/10.1080/03067319.2020.1772775

Yang, Z., Jie, G., Dong, F., Xu, Y., Watanabe, N., & Tu, Y. (2008). Radical-scavenging abilities and antioxidant properties of theaflavins and their gallate esters in H2O2-mediated oxidative damage system in the HPF-1 cells. *Toxicology in Vitro*, *22*(5), 1250–1256. https://doi.org/10.1016/j.tiv.2008.04.007

Yang, Z., Tu, Y., Xia, H., Jie, G., Chen, X., & He, P. (2007). Suppression of free-radicals and protection against H2O2-induced oxidative damage in HPF-1 cell by oxidized phenolic compounds present in black tea. *Food Chemistry*, *105*(4), 1349–1356. https://doi.org/10.1016/j.foodchem.2007.05.006

Yao, Q., Li, J., Yan, S. an, Huang, M., & Lin, Q. (2021). Occurrence of pesticides in white tea and a corresponding risk exposure assessment for the different residents in Fujian, China. *Journal of Food Science*, *86*(8), 3743–3754. https://doi.org/10.1111/1750-3841.15826

Yao, Q., Yan, S. A., Li, J., Huang, M., & Lin, Q. (2022). Health risk assessment of 42 pesticide residues in Tieguanyin tea from Fujian, China. *Drug and Chemical Toxicology*, *45*(2), 932–939. https://doi.org/10.1080/01480545.2020.1802476

Yigit, N., & Velioglu, Y. S. (2020). Effects of processing and storage on pesticide residues in foods. *Critical Reviews in Food Science and Nutrition*, *60*(21), 3622–3641. https://doi.org/10.1080/10408398.2019.1702501

Zhai, Y., Tian, J., Ping, R., Xiu, H., Xiang, Q., Shen, R., & Wang, Z. (2021). Effects of ultraviolet-C light-emitting diodes at 275 nm on inactivation of Alicyclobacillus acidoterrestris vegetative cells and its spores as well as the quality attributes of orange juice. *Food Science and Technology International*, *27*(4), 334–343. https://doi.org/10.1177/1082013220957529

Zhang, L., Ho, C. T., Zhou, J., Santos, J. S., Armstrong, L., & Granato, D. (2019). Chemistry and Biological Activities of Processed Camellia sinensis Teas: A Comprehensive Review. *Comprehensive Reviews in Food Science and Food*

Safety, *18*(5), 1474–1495. https://doi.org/10.1111/1541-4337.12479

Zhang, X., Mobley, N., Zhang, J., Zheng, X., Lu, L., Ragin, O., & Smith, C. J. (2010). Analysis of agricultural residues on tea using d-SPE sample preparation with GC-NCI-MS and UHPLC-MS/MS. *Journal of Agricultural and Food Chemistry*, *58*(22), 11553–11560. https://doi.org/10.1021/jf102476m

Zhang, Y., Zhang, J., Xiao, Y., Chang, V. W. C., & Lim, T. T. (2017). Direct and indirect photodegradation pathways of cytostatic drugs under UV germicidal irradiation: Process kinetics and influences of water matrix species and oxidant dosing. *Journal of Hazardous Materials*, *324*, 481–488. https://doi.org/10.1016/j.jhazmat.2016.11.016

Zheng, R., Yin, T., Chen, Z., Lin, X., Li, B., & Zhang, Y. (2023). Degradation of imidacloprid and acetamiprid in tea (Camellia sinensis) infusion by ultraviolet light irradiation. *Journal of Environmental Science and Health - Part B Pesticides, Food Contaminants, and Agricultural Wastes*, *58*(4), 316–326. https://doi.org/10.1080/03601234.2023.2188850

Zheng, X., Feng, M., Wan, J., Shi, Y., Xie, X., Pan, W., Hu, B., Wang, Y., Wen, H., Wang, K., & Cai, S. (2021). Anti-damage effect of theaflavin-3′-gallate from black tea on UVB-irradiated HaCaT cells by photoprotection and maintaining cell homeostasis. *Journal of Photochemistry and Photobiology B: Biology*, *224*(September), 112304. https://doi.org/10.1016/j.jphotobiol.2021.112304

Zhou, B., Wang, Z., Yin, P., Ma, B., Ma, C., Xu, C., Wang, J., Wang, Z., Yin, D., & Xia, T. (2022). Impact of prolonged withering on phenolic compounds and antioxidant capability in white tea using LC-MS-based metabolomics and HPLC analysis: Comparison with green tea. *Food Chemistry*, *368*(March 2021), 130855. https://doi.org/10.1016/j.foodchem.2021.130855

Zhu, Y., Koutchma, T., Warriner, K., Shao, S., & Zhou, T. (2013). Kinetics of patulin degradation in model solution, apple cider and apple juice by ultraviolet radiation. *Food Science and Technology International*, *19*(4), 291–303. https://doi.org/10.1177/1082013212452414