

**DAFTAR PUSTAKA**

- Alavarse, A. C., Frachini, E. C. G., da Silva, R. L. C. G., Lima, V. H., Shavandi, A., & Petri, D. F. S. (2022). Crosslinkers for polysaccharides and proteins: Synthesis conditions, mechanisms, and crosslinking efficiency, a review. *International Journal of Biological Macromolecules*, 202(December 2021), 558–596. <https://doi.org/10.1016/j.ijbiomac.2022.01.029>
- Alipal, J., Mohd Pu'ad, N. A. S., Lee, T. C., Nayan, N. H. M., Sahari, N., Basri, H., Idris, M. I., & Abdullah, H. Z. (2019). A review of gelatin: Properties, sources, process, applications, and commercialisation. *Materials Today: Proceedings*, 42, 240–250. <https://doi.org/10.1016/j.matpr.2020.12.922>
- Alizadeh, S. R., & Ebrahimzadeh, M. A. (2022). Quercetin derivatives: Drug design, development, and biological activities, a review. *European Journal of Medicinal Chemistry*, 229, 114068. <https://doi.org/10.1016/j.ejmech.2021.114068>
- Assi, R. A., Darwis, Y., Abdulbaqi, I. M., Khan, A. A., Vuanghao, L., & Laghari, M. H. (2017). *Morinda citrifolia* (Noni): A comprehensive review on its industrial uses , pharmacological activities , and clinical trials. *Arabian Journal of Chemistry*, 10(5), 691–707. <https://doi.org/10.1016/j.arabjc.2015.06.018>
- Augustin, M. A., & Sanguansri, L. (2008). Encapsulation of Bioactives. In J. M. Aguilera & P. J. Lillford (Eds.), *Food Materials Science: Principles and Practice*. Springer Science+Business Media, LLC. <https://doi.org/10.1007/978-0-387-71947-4>
- Baltacıoğlu, H., Baltacıoğlu, C., Okur, I., Tanrıvermiş, A., & Yalıç, M. (2021). Optimization of microwave-assisted extraction of phenolic compounds from tomato: Characterization by FTIR and HPLC and comparison with conventional solvent extraction. *Vibrational Spectroscopy*, 113(December 2020). <https://doi.org/10.1016/j.vibspec.2020.103204>
- Bhagya Raj, G. V. S., & Dash, K. K. (2022). Microencapsulation of betacyanin from dragon fruit peel by complex coacervation: Physicochemical characteristics, thermal stability, and release profile of microcapsules. *Food Bioscience*, 49(June). <https://doi.org/10.1016/j.fbio.2022.101882>
- Bounegru, A. V., Dima, S., & Apetrei, C. (2025). Determination of antioxidant capacity of glutathione encapsulated in alginate microcapsules using spectrophotometric and electrochemical methods. *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, 705(October 2024). <https://doi.org/10.1016/j.colsurfa.2024.135735>
- Brito de Souza, V., Thomazini, M., Chaves, I. E., Ferro-Furtado, R., & Favaro-Trindade, C. S. (2020). Microencapsulation by complex coacervation as a tool to protect bioactive compounds and to reduce astringency and strong flavor of vegetable extracts. *Food Hydrocolloids*, 98(July 2019), 105244. <https://doi.org/10.1016/j.foodhyd.2019.105244>
- Cao, S. qian, Liu, L., & Pan, S. yi. (2011). Thermal degradation kinetics of anthocyanins and visual color of blood orange juice. *Agricultural Sciences in China*, 10(12), 1992–1997. [https://doi.org/10.1016/S1671-2927\(11\)60201-0](https://doi.org/10.1016/S1671-2927(11)60201-0)



Cárdenas-Coronel, W. G., Carrillo-López, A., Vélez De La Rocha, R., Labavitch, J. M., Báez-Sañudo, M. A., Heredia, J. B., Zazueta-Morales, J. J., Vega-García, M. O., & Sañudo-Barajas, J. A. (2016). Biochemistry and Cell Wall Changes Associated with Noni (*Morinda citrifolia L.*) Fruit Ripening. *Journal of Agricultural and Food Chemistry*, 64(1), 302–309. <https://doi.org/10.1021/acs.jafc.5b03681>

Chan-Blanco, Y., Vaillant, F., Mercedes Perez, A., Reynes, M., Brillouet, J. M., & Brat, P. (2006). The noni fruit (*Morinda citrifolia L.*): A review of agricultural research, nutritional and therapeutic properties. *Journal of Food Composition and Analysis*, 19(6–7), 645–654. <https://doi.org/10.1016/j.jfca.2005.10.001>

Chang-hong, L., Ya-rong, X., Yong-hang, Y., Feng-feng, Y., Jun-yan, L., & Jing-lei, S. (2007). Extraction and Characterization of Antioxidant Compositions From Fermented Fruits Juice of *Morinda citrifolia* (Noni). *Agricultural Sciences in China*, 6 (12)(December), 1494–1501.

Chen, C. H., Lin, T. P., Chung, Y. L., Lee, C. K., Yeh, D. B., & Chen, S. Y. (2009). Determination of antioxidative properties of *Morinda citrifolia* using near supercritical fluid extraction. *Journal of Food and Drug Analysis*, 17(5), 333–341. <https://doi.org/10.38212/2224-6614.2592>

Chen, G., Dong, S., Chen, Y., Gao, Y., Zhang, Z., Li, S., & Chen, Y. (2020). Complex coacervation of zein-chitosan via atmospheric cold plasma treatment: Improvement of encapsulation efficiency and dispersion stability. *Food Hydrocolloids*, 107(29), 105943. <https://doi.org/10.1016/j.foodhyd.2020.105943>

Chen, L., Gnanaraj, C., Arulselvan, P., El-Seedi, H., & Teng, H. (2019). A review on advanced microencapsulation technology to enhance bioavailability of phenolic compounds: Based on its activity in the treatment of Type 2 Diabetes. *Trends in Food Science and Technology*, 85(November 2018), 149–162. <https://doi.org/10.1016/j.tifs.2018.11.026>

Choudhury, N., Meghwal, M., & Das, K. (2021). Microencapsulation: An overview on concepts, methods, properties and applications in foods. *Food Frontiers*, 2(4), 426–442. <https://doi.org/10.1002/fft2.94>

Comunian, T. A., Thomazini, M., Alves, A. J. G., de Matos Junior, F. E., de Carvalho Balieiro, J. C., & Favaro-Trindade, C. S. (2013). Microencapsulation of ascorbic acid by complex coacervation: Protection and controlled release. *Food Research International*, 52(1), 373–379. <https://doi.org/10.1016/j.foodres.2013.03.028>

Conde, E., Moure, A., Domínguez, H., & Parajó, J. C. (2010). Extraction of natural antioxidants from plant foods. In S. S. H. Rizvi (Ed.), *Separation, extraction and concentration processes in the food, beverage and nutraceutical industries* (pp. 506–594). Woodhead Publishing Limited.

Deng, S., West, B. J., & Jensen, C. J. (2010). A quantitative comparison of phytochemical components in global noni fruits and their commercial products. *Food Chemistry*, 122(1), 267–270. <https://doi.org/10.1016/j.foodchem.2010.01.031>

Devi, L. M., Das, A. B., & Badwaik, L. S. (2023). Effect of gelatin and acacia gum on anthocyanin coacervated microcapsules using double emulsion and its characterization. *International Journal of Biological Macromolecules*, 235(March). <https://doi.org/10.1016/j.ijbiomac.2023.123896>



Dussossoy, E., Brat, P., Bony, E., Boudard, F., Poucheret, P., Mertz, C., Giaimis, J., & Michel, A. (2011). Characterization, anti-oxidative and anti-inflammatory effects of Costa Rican noni juice (*Morinda citrifolia L.*). *Journal of Ethnopharmacology*, 133(1), 108–115. <https://doi.org/10.1016/j.jep.2010.08.063>

Emon, D. Das, Islam, M. S., Mazumder, M. A. R., Aziz, M. G., & Rahman, M. S. (2025). Recent applications of microencapsulation techniques for delivery of functional ingredient in food products: A comprehensive review. *Food Chemistry Advances*, 6(January). <https://doi.org/10.1016/j.focha.2025.100923>

Fan, S., Yang, Q., Wang, D., Zhu, C., Wen, X., Li, X., Richel, A., Fauconnier, M. L., Yang, W., Hou, C., & Zhang, D. (2024). Zein and tannic acid hybrid particles improving physical stability, controlled release properties, and antimicrobial activity of cinnamon essential oil loaded Pickering emulsions. *Food Chemistry*, 446(January), 138512. <https://doi.org/10.1016/j.foodchem.2024.138512>

Figueroa, J. G., Borrás-Linares, I., Del Pino-García, R., Curiel, J. A., Lozano-Sánchez, J., & Segura-Carretero, A. (2021). Functional ingredient from avocado peel: Microwave-assisted extraction, characterization and potential applications for the food industry. *Food Chemistry*, 352(February). <https://doi.org/10.1016/j.foodchem.2021.129300>

Foo, S. C., Yusoff, F. M., & Khong, N. M. H. (2024). Storage and degradation kinetics of physicochemical and bioactive attributes in microalgal-derived fucoxanthin-rich microcapsules. *Journal of Agriculture and Food Research*, 15(August 2023), 100823. <https://doi.org/10.1016/j.jafr.2023.100823>

Ford, W. (2015). *Numerical Linear Algebra with Applications Using MATLAB* (First edit). Elsevier Inc.

FORMULARIUM OBAT HERBAL ASLI INDONESIA, Pub. L. No. PERATURAN MENTERI KESEHATAN REPUBLIK INDONESIA NOMOR 6 TAHUN 2016 (2016).

García-Saldaña, J. S., Campas-Baypoli, O. N., López-Cervantes, J., Sánchez-Machado, D. I., Cantú-Soto, E. U., & Rodríguez-Ramírez, R. (2016). Microencapsulation of sulforaphane from broccoli seed extracts by gelatin/gum Arabic and gelatin/pectin complexes. *Food Chemistry*, 201, 94–100. <https://doi.org/10.1016/j.foodchem.2016.01.087>

Gonçalves, N. D., Grosso, C. R. F., Rabelo, R. S., Hubinger, M. D., & Prata, A. S. (2018). Comparison of microparticles produced with combinations of gelatin, chitosan and gum Arabic. *Carbohydrate Polymers*, 196(April), 427–432. <https://doi.org/10.1016/j.carbpol.2018.05.027>

Guimarães, S., Almeida, L., Aguiar, D. De, Vieira, T., Brito, D., Arruda, J., Maria, C., Pereira, C., Souza, M. De, Carlos, J., Mazulo, R., Carvalho, M. De, Fernando, D., Vasconcelos, P., Alves, D., Clark, F., Barros, N., Sombra, V. G., Lúcia, A., ... Feitosa, D. A. (2018). Chemical structure and anti-inflammatory effect of polysaccharide extracted from *Morinda citrifolia* Linn (Noni). *Carbohydrate Polymers*, 197(2819), 515–523. <https://doi.org/10.1016/j.carbpol.2018.06.042>

Gullón, B., Lú-Chau, T. A., Moreira, M. T., Lema, J. M., & Eibes, G. (2017). Rutin: A review on extraction, identification and purification methods, biological activities



Guo, M., Mao, B., Ahmed Sadiq, F., Hao, Y., Cui, S., Yi, M., Hong, Q., Lee, Y. K., & Zhao, J. (2020). Effects of noni fruit and fermented noni juice against acute alcohol induced liver injury in mice. *Journal of Functional Foods*, 70(December 2019), 103995. <https://doi.org/10.1016/j.jff.2020.103995>

Guo, Q., Li, S., Du, G., Chen, H., Yan, X., Chang, S., Yue, T., & Yuan, Y. (2022). Formulation and characterization of microcapsules encapsulating carvacrol using complex coacervation crosslinked with tannic acid. *Lwt*, 165(June), 113683. <https://doi.org/10.1016/j.lwt.2022.113683>

Hay, T. O., Kontogiorgos, V., Thompson, S., Nastasi, J. R., & Fitzgerald, M. (2024). A new hydrocolloid to rival gum Arabic: Characterisation of a traditional food gum from Australian Acacia cambagei. *Food Hydrocolloids*, 153(January), 110003. <https://doi.org/10.1016/j.foodhyd.2024.110003>

Hemwimon, S., Pavasant, P., & Shotipruk, A. (2007). Microwave-assisted extraction of antioxidative anthraquinones from roots of *Morinda citrifolia*. *Separation and Purification Technology*, 54(1), 44–50. <https://doi.org/10.1016/j.seppur.2006.08.014>

Huang, Q., & Zhang, Z. (2024). *Green Chemical Engineering Evaluation of gum Arabic and gelatine coacervated microcapsule morphology and core oil encapsulation efficiency by combining the spreading coefficient and two component surface energy theory*. August.

Insang, S., Kijpatanasilp, I., Jafari, S., & Assatarakul, K. (2022). Ultrasound-assisted extraction of functional compound from mulberry (*Morus alba L.*) leaf using response surface methodology and effect of microencapsulation by spray drying on quality of optimized extract. *Ultrasonics Sonochemistry*, 82. <https://doi.org/10.1016/j.ultsonch.2021.105806>

Irianti, T., Puspitasari, A., Lukman, M., & Rabbani. (2015). The Activity Of Radical Scavenging Of 2,2-Diphenyl-1-Pycrilhydrazil (DPPH) By Ethanolic Extracts Of Mengkudu Leaves (*Morinda Citrifolia L.*), Brotowali Stem (*Tinospora Crispa L.*), Its Water Fraction And Its Hydrolized Fraction. *Majalah Obat Tradisional (Traditional Medicine Journal)*, 20(3), 142.

ISO 22412:2017(En), Particle Size Analysis — Dynamic Light Scattering (DLS), ISO 22412:2017 Particle size analysis — Dynamic light scattering (DLS) (2017). <https://www.iso.org/obp/ui/#iso:std:iso:22412:ed-2:v1:en>

Jadresko, D., Milicevic, A., & Jovanovic, I. N. (2022). Reactivity of flavonoids toward superoxide radical : An electrochemical approach. *Electrochimica Acta*, 421(5 May 2022). <https://doi.org/10.1016/j.electacta.2022.140501>

Jamaludin, R., Kim, D. S., Md Salleh, L., & Lim, S. Bin. (2020). Optimization of high hydrostatic pressure extraction of bioactive compounds from noni fruits. *Journal of Food Measurement and Characterization*, 14(5), 2810–2818. <https://doi.org/10.1007/s11694-020-00526-w>

Kaderides, K., Papaoikonomou, L., Serafim, M., & Goula, A. M. (2019). Microwave-assisted extraction of phenolics from pomegranate peels: Optimization, kinetics,



Kara, Ş., & Ercelеби, E. A. (2013). Thermal degradation kinetics of anthocyanins and visual colour of Urmu mulberry (*Morus nigra L.*). *Journal of Food Engineering*, 116(2), 541–547. <https://doi.org/10.1016/j.jfoodeng.2012.12.030>

Karagozlu, M., Ocak, B., & Özdestan-Ocak, Ö. (2021). Effect of Tannic Acid Concentration on the Physicochemical, Thermal, and Antioxidant Properties of Gelatin/Gum Arabic-Walled Microcapsules Containing *Origanum onites* L. Essential Oil. *Food and Bioprocess Technology*, 14(7), 1231–1243. <https://doi.org/10.1007/s11947-021-02633-y>

Kementerian Kesehatan RI. (2017). *Farmakope Herbal Indonesia Edisi II*. <https://doi.org/10.2307/jj.2430657.12>

Kha, T. C., Nguyen, M. H., Roach, P. D., & Stathopoulos, C. E. (2015). A storage study of encapsulated gac (*Momordica cochinchinensis*) oil powder and its fortification into foods. *Food and Bioproducts Processing*, 96, 113–125. <https://doi.org/10.1016/j.fbp.2015.07.009>

Kim, A. N., Kim, H. J., Chun, J., Heo, H. J., Kerr, W. L., & Choi, S. G. (2018). Degradation kinetics of phenolic content and antioxidant activity of hardy kiwifruit (*Actinidia arguta*) puree at different storage temperatures. *Lwt*, 89(November 2017), 535–541. <https://doi.org/10.1016/j.lwt.2017.11.036>

Koley, T. K., Maurya, A., Tripathi, A., Singh, B. K., Singh, M., Bhutia, T. L., Tripathi, P. C., & Singh, B. (2019). Antioxidant potential of commonly consumed underutilized leguminous vegetables. *International Journal of Vegetable Science*, 25(4), 362–372. <https://doi.org/10.1080/19315260.2018.1519866>

Krishnaiah, D., Bono, A., Sarbatly, R., & Anisuzzaman, S. M. (2015). Antioxidant activity and total phenolic content of an isolated *Morinda citrifolia L.* methanolic extract from Poly-ethersulphone (PES) membrane separator. *Journal of King Saud University - Engineering Sciences*, 27(1), 63–67. <https://doi.org/10.1016/j.jksues.2013.01.002>

Krishnaiah, D., Bono, A., Sarbatly, R., Nithyanandam, R., & Anisuzzaman, S. M. (2015). Optimisation of spray drying operating conditions of *Morinda citrifolia L.* fruit extract using response surface methodology. *Journal of King Saud University - Engineering Sciences*, 27(1), 26–36. <https://doi.org/10.1016/j.jksues.2012.10.004>

Krishnaiah, D., Sarbatly, R., & Nithyanandam, R. (2011). Microencapsulation of *Morinda citrifolia L.* extract by spray-drying. *Chemical Engineering Research and Design*, 90(5), 622–632. <https://doi.org/10.1016/j.cherd.2011.09.003>

Kumar, A., Kaur, R., Kumar, V., Kumar, S., Gehlot, R., & Aggarwal, P. (2022). New insights into water-in-oil-in-water (W/O/W) double emulsions: Properties, fabrication, instability mechanism, and food applications. *Trends in Food Science and Technology*, 128(March), 22–37. <https://doi.org/10.1016/j.tifs.2022.07.016>

Lee, S. J., & Wong, M. (2014). Nano- and Microencapsulation of Phytochemicals. In H.-S. Kwak (Ed.), *Nano- and Microencapsulation for Foods* (pp. 119–165). John Wiley & Sons, Ltd.



- Lee, W. J., Tan, C. P., Sulaiman, R., Hee, Y. Y., & Chong, G. H. (2020). Storage stability and degradation kinetics of bioactive compounds in red palm oil microcapsules produced with solution-enhanced dispersion by supercritical carbon dioxide: A comparison with the spray-drying method. *Food Chemistry*, 304(August 2019). <https://doi.org/10.1016/j.foodchem.2019.125427>
- Li, J., Niu, D., Zhang, Y., & Zeng, X. A. (2020). Physicochemical properties, antioxidant and antiproliferative activities of polysaccharides from *Morinda citrifolia L.* (Noni) based on different extraction methods. *International Journal of Biological Macromolecules*, 150, 114–121. <https://doi.org/10.1016/j.ijbiomac.2019.12.157>
- Li, Y., Fabiano-Tixier, A.-S., Abert-Vian, M., & Chemat, F. (2013). Microwave-Assisted Extraction of Antioxidants and Food Colors. In F. Chemat & G. Cravotto (Eds.), *Microwave-assisted Extraction for Bioactive Compounds* (pp. 103–125). Springer Science+Business Media.
- Lin, Y. L., Chang, Y. Y., Yang, D. J., Tzang, B. S., & Chen, Y. C. (2013). Beneficial effects of noni (*Morinda citrifolia L.*) juice on livers of high-fat dietary hamsters. *Food Chemistry*, 140(1–2), 31–38. <https://doi.org/10.1016/j.foodchem.2013.02.035>
- Ling, J. K. U., Chan, Y. S., & Nandong, J. (2021). Degradation kinetics modeling of antioxidant compounds from the wastes of *Mangifera pajang* fruit in aqueous and choline chloride/ascorbic acid natural deep eutectic solvent. *Journal of Food Engineering*, 294(July 2020). <https://doi.org/10.1016/j.jfoodeng.2020.110401>
- Liu, Y., Wei, Z.-C., Deng, Y.-Y., Dong, H., Zhang, Y., Tang, X.-J., Li, P., Liu, G., & Zhang, M.-W. (2020). Comparison of the Effects of Different Food-Grade Emulsifiers on the Properties and Stability of a. *Molecules*, 25(3), 458–474.
- Lohani, M., Majrashi, M., Govindarajulu, M., Patel, M., Ramesh, S., Bhattacharya, D., Joshi, S., Fadan, M., Nadar, R., Darien, B., Maurice, D. V., Kemppainen, B., & Dhanasekaran, M. (2019). Immunomodulatory actions of a Polynesian herb Noni (*Morinda citrifolia*) and its clinical applications. *Complementary Therapies in Medicine*, 47(June), 102206. <https://doi.org/10.1016/j.ctim.2019.102206>
- Lopes, M. M. de A., Sanches, A. G., Sousa, J. A. De, & Silva, E. de O. (2018). Noni—*Morinda citrifolia L.* In S. Rodrigues, E. de O. Silva, & E. S. de Brito (Eds.), *Exotic Fruits Reference Guide* (pp. 319–325). Elsevier Inc.
- López, A. C., & Yahia, E. M. (2011). Noni (*Morinda citrifolia L.*). In E. M. Yahia (Ed.), *Postharvest Biology and Technology of Tropical and Subtropical Fruits Volume 4 : Mangosteen to White Sapote* (pp. 51–62). Woodhead Publishing Limited.
- Lu, W., Yang, X., Shen, J., Li, Z., Tan, S., Liu, W., & Cheng, Z. (2021). Choosing the appropriate wall materials for spray-drying microencapsulation of natural bioactive ingredients: Taking phenolic compounds as examples. *Powder Technology*, 394, 562–574. <https://doi.org/10.1016/j.powtec.2021.08.082>
- Luque de Castro, M. D., & Castillo-Peinado, L. S. (2016). Microwave-Assisted Extraction of Food Components. In K. Knoerzer, P. Juliano, & G. Smithers (Eds.), *Innovative Food Processing Technologies (Extraction, Separation, Component Modification, and Process Intensification)* (Woodhead P, pp. 57–110). Elsevier



Lv, Y., Yang, F., Li, X., Zhang, X., & Abbas, S. (2014). Formation of heat-resistant nanocapsules of jasmine essential oil via gelatin/gum arabic based complex coacervation. *Food Hydrocolloids*, 35, 305–314.
<https://doi.org/10.1016/j.foodhyd.2013.06.003>

MacHado, Y. L., Teles, U. M., Dantas Neto, A. A., Dantas, T. N. C., & Fonseca, J. L. C. (2013). Determination of antioxidant depletion kinetics using ASTMD 7545 as the accelerated oxidation method. *Fuel*, 112, 172–177.
<https://doi.org/10.1016/j.fuel.2013.04.080>

Mahattanadul, S., Ridtitid, W., Nima, S., Phdoongsombut, N., Ratanasuwon, P., & Kasiwong, S. (2011a). Effects of *Morinda citrifolia* aqueous fruit extract and its biomarker scopoletin on reflux esophagitis and gastric ulcer in rats. *Journal of Ethnopharmacology*, 134(2), 243–250. <https://doi.org/10.1016/j.jep.2010.12.004>

Mahattanadul, S., Ridtitid, W., Nima, S., Phdoongsombut, N., Ratanasuwon, P., & Kasiwong, S. (2011b). Effects of *Morinda citrifolia* aqueous fruit extract and its biomarker scopoletin on reflux esophagitis and gastric ulcer in rats. *Journal of Ethnopharmacology*, 134(2), 243–250. <https://doi.org/10.1016/j.jep.2010.12.004>

Menezes, M. do L. L. R., Pires, N. da R., da Cunha, P. L. R., de Freitas Rosa, M., de Souza, B. W. S., Feitosa, J. P. de A., & Souza Filho, M. de S. M. de. (2019). Effect of tannic acid as crosslinking agent on fish skin gelatin-silver nanocomposite film. *Food Packaging and Shelf Life*, 19(March 2018), 7–15.
<https://doi.org/10.1016/j.fpsl.2018.11.005>

Montenegro-Landívar, M. F., Tapia-Quirós, P., Vecino, X., Reig, M., Valderrama, C., Granados, M., Cortina, J. L., & Saurina, J. (2021). Polyphenols and their potential role to fight viral diseases: An overview. *Science of the Total Environment*, 801. <https://doi.org/10.1016/j.scitotenv.2021.149719>

Motshakeri, M., & Ghazali, H. M. (2015). Nutritional, phytochemical and commercial quality of Noni fruit: A multi-beneficial gift from nature. *Trends in Food Science and Technology*, 45(1), 118–129. <https://doi.org/10.1016/j.tifs.2015.06.004>

Musa, H. H., Ahmed, A. A., & Musa, T. H. (2019). Chemistry, Biological, and Pharmacological Properties of Gum Arabic. In J.-M. Mérillon & K. G. Ramawat (Eds.), *Bioactive Molecules in Food* (pp. 797–814). Springer Nature.

Nakagawa, K. (2014). Nano- and Microencapsulation of Flavor in Food Systems. In H.-S. Kwak (Ed.), *Nano- and Microencapsulation for Foods* (pp. 249–271). John Wiley & Sons, Ltd.

Nezamdoost-Sani, N., Amiri, S., & Mousavi Khaneghah, A. (2024). The application of the coacervation technique for microencapsulation bioactive ingredients: A critical review. *Journal of Agriculture and Food Research*, 18(September), 101431.
<https://doi.org/10.1016/j.jafr.2024.101431>

Nguyen, C. T., Nguyen Di, K., Phan, H. C., Kha, T. C., & Nguyen, H. C. (2024). Microencapsulation of noni fruit extract using gum arabic and maltodextrin – Optimization, stability and efficiency. *International Journal of Biological Macromolecules*, 269(P2), 132217. <https://doi.org/10.1016/j.ijbiomac.2024.132217>



- Odabaş, H. İ., & Koca, I. (2021). Simultaneous separation and preliminary purification of anthocyanins from Rosa pimpinellifolia L. fruits by microwave assisted aqueous two-phase extraction. *Food and Bioproducts Processing*, 125, 170–180. <https://doi.org/10.1016/j.fbp.2020.11.007>
- Oxley, J. (2014). Overview of Microencapsulation Process Technologies. In A. G. Gaonkar, N. Vasisht, A. R. Khare, & R. Sobel (Eds.), *Microencapsulation in the Food Industry A Practical Implementation Guide* (pp. 35–46). Elsevier Inc.
- Ozkan, G., Franco, P., De Marco, I., Xiao, J., & Capanoglu, E. (2019). A review of microencapsulation methods for food antioxidants: Principles, advantages, drawbacks and applications. *Food Chemistry*, 272(August 2018), 494–506. <https://doi.org/10.1016/j.foodchem.2018.07.205>
- Pakzad, H., Alemzadeh, I., & Kazemi, A. (2013). Encapsulation of peppermint oil with arabic gum-gelatin by complex coacervation method. *International Journal of Engineering, Transactions B: Applications*, 26(8), 807–814. <https://doi.org/10.5829/idosi.ije.2013.26.08b.01>
- Patle, T. K., Shrivastava, K., Kurrey, R., Upadhyay, S., Jangde, R., & Chauhan, R. (2020). Phytochemical screening and determination of phenolics and flavonoids in Dillenia pentagyna using UV-vis and FTIR spectroscopy. *Spectrochimica Acta - Part A: Molecular and Biomolecular Spectroscopy*, 242. <https://doi.org/10.1016/j.saa.2020.118717>
- Paula, D. de A., Martins, E. M. F., Costa, N. de A., de Oliveira, P. M., de Oliveira, E. B., & Ramos, A. M. (2019). Use of gelatin and gum arabic for microencapsulation of probiotic cells from *Lactobacillus plantarum* by a dual process combining double emulsification followed by complex coacervation. *International Journal of Biological Macromolecules*, 133, 722–731. <https://doi.org/10.1016/j.ijbiomac.2019.04.110>
- Peng, C., Zhao, S. Q., Zhang, J., Huang, G. Y., Chen, L. Y., & Zhao, F. Y. (2014). Chemical composition, antimicrobial property and microencapsulation of Mustard (*Sinapis alba*) seed essential oil by complex coacervation. *Food Chemistry*, 165, 560–568. <https://doi.org/10.1016/j.foodchem.2014.05.126>
- Perkampus, H.-H. (1992). *UV-VIS spectroscopy and its applications* (H. C. Griner & T. L. Threlfall (eds.)). Springer-Verlag Berlin Heidelberg.
- Persyaratan Keamanan Mutu Dan Obat Tradisional, Pub. L. No. PERATURAN BADAN PENGAWAS OBAT DAN MAKANAN RI NOMOR 32 TAHUN 2019 (2019).
- Picchio, M. L., Linck, Y. G., Monti, G. A., Gugliotta, L. M., Minari, R. J., & Alvarez Igazabal, C. I. (2018). Casein films crosslinked by tannic acid for food packaging applications. *Food Hydrocolloids*, 84(April), 424–434. <https://doi.org/10.1016/j.foodhyd.2018.06.028>
- Pinho de Moraes, G., Barros de Alencar, M. V. O., Araújo, L. da S., Gomes, D. C. V., Paz, M. F. C. J., Islam, M. T., Melo-Cavalcante, A. A. de C., & Picada, J. N. (2019). Cytogenotoxic study of aqueous fruit extract of *Morinda citrifolia* in Wistar albino rats. *Oriental Pharmacy and Experimental Medicine*, 19(3), 311–321. <https://doi.org/10.1007/s13596-019-00358-0>



Praveen, S., & He, J. (2020). *Microencapsulation of vitamins in food applications to prevent losses in processing and storage : A review*. 137(May).

Ribeiro, E. F., Morell, P., Nicoletti, V. R., Quiles, A., & Hernando, I. (2021). Protein- and polysaccharide-based particles used for Pickering emulsion stabilisation. *Food Hydrocolloids*, 119(January), 106839.
<https://doi.org/10.1016/j.foodhyd.2021.106839>

Rivero, S., García, M. A., & Pinotti, A. (2010). Crosslinking capacity of tannic acid in plasticized chitosan films. *Carbohydrate Polymers*, 82(2), 270–276.
<https://doi.org/10.1016/j.carbpol.2010.04.048>

Riyanto, S., & Rohman, A. (2007). Isolasi Skopoletin dari Buah Mengkudu (*Morinda citrifolia L.*) dan Uji Aktivitas Antioksidannya. *Agritech*, 27(3), 107–111.

Rocha-Selmi, G. A., Bozza, F. T., Thomazini, M., Bolini, H. M. A., & Fávaro-Trindade, C. S. (2013). Microencapsulation of aspartame by double emulsion followed by complex coacervation to provide protection and prolong sweetness. *Food Chemistry*, 139(1–4), 72–78. <https://doi.org/10.1016/j.foodchem.2013.01.114>

Rodríguez, J., Martín, M. J., Ruiz, M. A., & Clares, B. (2016). Current encapsulation strategies for bioactive oils: From alimentary to pharmaceutical perspectives. *Food Research International*, 83, 41–59. <https://doi.org/10.1016/j.foodres.2016.01.032>

Rosen, M. J., & Kunjappu, J. T. (2012). *SURFACTANTS AND INTERFACIAL PHENOMENA* (FOURTH). John Wiley & Sons, Inc.

Rousi, Z., Malhiac, C., Fatouros, D. G., & Paraskevopoulou, A. (2019). Complex coacervates formation between gelatin and gum Arabic with different arabinogalactan protein fraction content and their characterization. *Food Hydrocolloids*, 96(January), 577–588.
<https://doi.org/10.1016/j.foodhyd.2019.06.009>

Ruhomally, Z., Somanah, J., Bahorun, T., & Neergheen-Bhujun, V. S. (2016). *Morinda citrifolia L.* fruit extracts modulates H₂O₂-induced oxidative stress in human liposarcoma SW872 cells. *Journal of Traditional and Complementary Medicine*, 6(3), 299–304. <https://doi.org/10.1016/j.jtcme.2015.09.003>

Samakradhamrongthai, R. S., Thakeow Angeli, P., Kopermsub, P., & Utama-ang, N. (2019). Optimization of gelatin and gum arabic capsule infused with pandan flavor for multi-core flavor powder encapsulation. *Carbohydrate Polymers*, 226(August). <https://doi.org/10.1016/j.carbpol.2019.115262>

Sanchez, C., Nigen, M., Mejia Tamayo, V., Doco, T., Williams, P., Amine, C., & Renard, D. (2018). Acacia gum: History of the future. *Food Hydrocolloids*, 78, 140–160. <https://doi.org/10.1016/j.foodhyd.2017.04.008>

Santos, T. M., Souza Filho, M. de S. M., Silva, E. de O., Silveira, M. R. S. d., Miranda, M. R. A. d., Lopes, M. M. A., & Azereedo, H. M. C. (2018). Enhancing storage stability of guava with tannic acid-crosslinked zein coatings. *Food Chemistry*, 257(December 2017), 252–258. <https://doi.org/10.1016/j.foodchem.2018.03.021>

Schrieber, R., & Gareis, H. (2007). *Gelatine Handbook: Theory and Industrial Practice*. WILEY-VCH Verlag GmbH & Co. KGaA.

Shaddel, R., Hesari, J., Azadmard-Damirchi, S., Hamishehkar, H., Fathi-Achachlouei,



B., & Huang, Q. (2018a). Double emulsion followed by complex coacervation as a promising method for protection of black raspberry anthocyanins. *Food Hydrocolloids*, 77, 803–816. <https://doi.org/10.1016/j.foodhyd.2017.11.024>

Shaddel, R., Hesari, J., Azadmard-Damirchi, S., Hamishehkar, H., Fathi-Achachlouei,

B., & Huang, Q. (2018b). Use of gelatin and gum Arabic for encapsulation of black raspberry anthocyanins by complex coacervation. *International Journal of Biological Macromolecules*, 107, 1800–1810.

<https://doi.org/10.1016/j.ijbiomac.2017.10.044>

Shaddel, R., Hesari, J., Azadmard-Damirchi, S., Hamishehkar, H., Fathi-Achachlouei,

B., & Huang, Q. (2018c). Use of gelatin and gum Arabic for encapsulation of black raspberry anthocyanins by complex coacervation. *International Journal of Biological Macromolecules*, 107, 1800–1810.

<https://doi.org/10.1016/j.ijbiomac.2017.10.044>

Shishir, M. R. I., & Chen, W. (2017). Trends of spray drying: A critical review on

drying of fruit and vegetable juices. *Trends in Food Science and Technology*, 65, 49–67. <https://doi.org/10.1016/j.tifs.2017.05.006>

Singh, D. R. S. S. (2013). *Phytochemicals in Plant Parts of Noni (Morinda citrifolia L.) with Special Reference to Fatty Acid Profiles of Seeds*. 83(3), 471–478.

<https://doi.org/10.1007/s40011-013-0154-1>

Sonar, M. P., & Rathod, V. K. (2020). Microwave assisted extraction (MAE) used as a

tool for rapid extraction of Marmelosin from Aegle marmelos and evaluations of total phenolic and flavonoids content, antioxidant and anti-inflammatory activity.

Chemical Data Collections, 30, 100545. <https://doi.org/10.1016/j.cdc.2020.100545>

Tasfiyati, A. N., Antika, L. D., Dewi, R. T., Septama, A. W., Sabarudin, A., &

Ernawati, T. (2022). An experimental design approach for the optimization of scopoletin extraction from *Morinda citrifolia L.* using accelerated solvent extraction. *Talanta*, 238(P1), 123010.

<https://doi.org/10.1016/j.talanta.2021.123010>

Tavares, L., & Noreña, C. P. Z. (2020). Encapsulation of Ginger Essential Oil Using

Complex Coacervation Method: Coacervate Formation, Rheological Property, and Physicochemical Characterization. *Food and Bioprocess Technology*, 13(8), 1405–1420. <https://doi.org/10.1007/s11947-020-02480-3>

Thies, C. (2007). Microencapsulation of Flavors by Complex Coacervation. In J. M.

Lakkis (Ed.), *Encapsulation and Controlled Release Technologies in Food Systems* (pp. 149–170). Blackwell Publishing.

Thoo, Y. Y., Ho, S. K., Liang, J. Y., Ho, C. W., & Tan, C. P. (2010). Effects of binary

solvent extraction system, extraction time and extraction temperature on phenolic antioxidants and antioxidant capacity from mengkudu (*Morinda citrifolia*). *Food Chemistry*, 120(1), 290–295. <https://doi.org/10.1016/j.foodchem.2009.09.064>

Timilsena, Y. P., Akanbi, T. O., Khalid, N., Adhikari, B., & Barrow, C. J. (2019).

Complex coacervation: Principles, mechanisms and applications in microencapsulation. *International Journal of Biological Macromolecules*, 121, 1276–1286. <https://doi.org/10.1016/j.ijbiomac.2018.10.144>

Tontul, I., & Topuz, A. (2017). Spray-drying of fruit and vegetable juices: Effect of



drying conditions on the product yield and physical properties. *Trends in Food Science and Technology*, 63, 91–102. <https://doi.org/10.1016/j.tifs.2017.03.009>

Tyuftin, A. A., & Kerry, J. P. (2021). Gelatin films : Study review of barrier properties and implications for future studies employing biopolymer films. *Food Packaging and Shelf Life*, 29(May), 100688. <https://doi.org/10.1016/j.fpsl.2021.100688>

Utatsu, K., Motoyama, K., Nakamura, T., Onodera, R., & Higashi, T. (2023). Tannic acid-based sustained-release system for protein drugs. *International Journal of Pharmaceutics*, 643(June), 123229. <https://doi.org/10.1016/j.ijpharm.2023.123229>

Vasisht, N. (2014). Factors and Mechanisms in Microencapsulation. In A. G. Gaonkar, N. Vasisht, A. R. Khare, & R. Sobel (Eds.), *Microencapsulation in the Food Industry A Practical Implementation Guide* (pp. 15–24). Elsevier Inc.

Veggi, P. C., Martinez, J., & Meireles, M. A. A. (2013). Fundamentals of Microwave Extraction. In F. Chemat & G. Cravotto (Eds.), *Microwave-assisted Extraction for Bioactive Compounds: Theory and Practice* (pp. 15–52). Springer Science+Business Media.

Vetal, M. D., Chavan, R. S., & Rathod, V. K. (2014). Microwave assisted extraction of ursolic acid and oleanolic acid from *Ocimum sanctum*. *Biotechnology and Bioprocess Engineering*, 19(4), 720–726. <https://doi.org/10.1007/s12257-013-0798-y>

Vila, M. M. D. C., Chaud, M. V., & Balcao, V. M. (2015). Microencapsulation of Natural Anti-Oxidant Pigments. In L. M. C. Sagis (Ed.), *Microencapsulation and Microspheres for Food Applications* (pp. 369–389). Academic Press Elsevier Inc.

Villaño, D., Fernández-Pachón, M. S., Moyá, M. L., Troncoso, A. M., & García-Parrilla, M. C. (2007). Radical scavenging ability of polyphenolic compounds towards DPPH free radical. *Talanta*, 71(1), 230–235. <https://doi.org/10.1016/j.talanta.2006.03.050>

Vorobiev, E., & Chemat, F. (2010). Principles of physically assisted extractions and applications in the food, beverage and nutraceutical industries. In S. S. H. Rizvi (Ed.), *Separation, extraction and concentration processes in the food, beverage and nutraceutical industries* (pp. 71–108). Woodhead Publishing Limited.

Wang, S., Liu, Z., Zhao, S., Zhang, L., Li, C., & Liu, S. (2023). Effect of combined ultrasonic and enzymatic extraction technique on the quality of noni (*Morinda citrifolia L.*) juice. *Ultrasonics Sonochemistry*, 92(November 2022), 106231. <https://doi.org/10.1016/j.ultsonch.2022.106231>

Wang, W. D., & Xu, S. Y. (2007). Degradation kinetics of anthocyanins in blackberry juice and concentrate. *Journal of Food Engineering*, 82(3), 271–275. <https://doi.org/10.1016/j.jfoodeng.2007.01.018>

Wang, Y., Wu, C., Yang, W., Gong, Y., Zhang, X., Li, J., & Wu, D. (2025). Dual cross-linking with tannic acid and transglutaminase improves microcapsule stability and encapsulates lemon essential oil for food preservation. *Food Chemistry*, 465(P2), 142173. <https://doi.org/10.1016/j.foodchem.2024.142173>

Waterhouse, A. L. (2001). Determination of Total Phenolics. In R. E. Wrolstad, T. E. Acree, H. An, E. A. Decker, M. H. Penner, D. S. Reid, S. J. Schwart, C. F.



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Ekstraksi dengan Teknik Koaservasi Kompleks Menggunakan Gelatin dan Gum Arab

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Shoemaker, D. M. Smith, & P. Sporns (Eds.), *Current Protocols in Food*

Analytical Chemistry. John Wiley & Sons, Inc.

<https://doi.org/10.1002/0471142913>

Wei, P., Zhang, Y., Wang, Y. Y., Dong, J. F., Lin, Z. H., Li, W., Liu, L., Hu, S. L., Zhang, L., Lou, W. Y., & Peng, C. (2023). Efficient extraction and excellent activity of flavonoid from *Moringa oleifera* leaves and its microencapsulation. *Lwt*, 184(May). <https://doi.org/10.1016/j.lwt.2023.115021>

Weisany, W., Yousefi, S., Tahir, N. A. razzak, Golestanehzadeh, N., McClements, D. J., Adhikari, B., & Ghasemlou, M. (2022). Targeted delivery and controlled released of essential oils using nanoencapsulation: A review. *Advances in Colloid and Interface Science*, 303(March), 102655. <https://doi.org/10.1016/j.cis.2022.102655>

West, B. J., Jensen, C. J., Westendorf, J., & White, L. D. (2006). A safety review of noni fruit juice. *Journal of Food Science*, 71(8). <https://doi.org/10.1111/j.1750-3841.2006.00164.x>

Williams, P. A., & Phillips, G. O. (2009). Gum Arabic. In G. O. Phillips & P. A. Williams (Eds.), *Handbook of Hydrocolloids* (Second edi, pp. 252–273). Woodhead Publishing Limited.

Wu, T., Li, M., & Lan, Z. (2019). Reveal the Variation Patterns of Chemical Composition in the Fruit of *Morinda citrifolia* (noni) during Postharvest Storage through Metabolomic Characterization. *Tropical Plant Biology*, 85–97. <https://doi.org/10.1007/s12042-019-09222-6>

Xie, A., Zhao, S., Liu, Z., Yue, X., Shao, J., Li, M., & Li, Z. (2023). Polysaccharides, proteins, and their complex as microencapsulation carriers for delivery of probiotics: A review on carrier types and encapsulation techniques. *International Journal of Biological Macromolecules*, 242(P1), 124784. <https://doi.org/10.1016/j.ijbiomac.2023.124784>

Yan, C., & Zhang, W. (2014). Coacervation Processes. In A. G. Gaonkar, N. Vasisht, A. R. Khare, & R. Sobel (Eds.), *Microencapsulation in the Food Industry A Practical Implementation Guide* (pp. 125–137). Elsevier Inc.

Yang, J., Gadi, R., Paulino, R., & Thomson, T. (2010). Total phenolics, ascorbic acid, and antioxidant capacity of noni (*Morinda citrifolia L.*) juice and powder as affected by illumination during storage. *Food Chemistry*, 122(3), 627–632. <https://doi.org/10.1016/j.foodchem.2010.03.022>

Yang, J., Paulino, R., Janke-Stedronsky, S., & Abawi, F. (2007). Free-radical-scavenging activity and total phenols of noni (*Morinda citrifolia L.*) juice and powder in processing and storage. *Food Chemistry*, 102(1), 302–308. <https://doi.org/10.1016/j.foodchem.2006.05.020>

Yu, J., Du, G., Yao, Y., Liao, Q., Zhou, T., Cui, H., Hussain, S., Hayat, K., Zhang, X., & Ho, C. T. (2025). Microencapsulation of glutathione through water/oil emulsification and complex coacervation: Improved encapsulation efficiency, physicochemical stability, and sustained release effect. *Food Research International*, 202(January). <https://doi.org/10.1016/j.foodres.2025.115723>

Zeb, A. (2021). *Phenolic Antioxidants in Foods: Chemistry, Biochemistry and Analysis*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-74768-8>



Zhang, C., Ada Khoo, S. L., Chen, X. D., & Quek, S. Y. (2020). Microencapsulation of fermented noni juice via micro-fluidic-jet spray drying: Evaluation of powder properties and functionalities. *Powder Technology*, 361, 995–1005.
<https://doi.org/10.1016/j.powtec.2019.10.098>

Zhang, C., Chen, X., Zhang, J., Kilmartin, P. A., & Quek, S. Y. (2020). Exploring the effects of microencapsulation on odour retention of fermented noni juice. *Journal of Food Engineering*, 273(June 2019), 109892.
<https://doi.org/10.1016/j.jfoodeng.2019.109892>

Zhang, C., Quek, S. Y., Fu, N., Liu, B., Kilmartin, P. A., & Chen, X. D. (2019). A study on the structure formation and properties of noni juice microencapsulated with maltodextrin and gum acacia using single droplet drying. *Food Hydrocolloids*, 88(July 2018), 199–209. <https://doi.org/10.1016/j.foodhyd.2018.10.002>

Zhang, W., Roy, S., Ezati, P., Yang, D. P., & Rhim, J. W. (2023). Tannic acid: A green crosslinker for biopolymer-based food packaging films. *Trends in Food Science and Technology*, 136(March), 11–23. <https://doi.org/10.1016/j.tifs.2023.04.004>

Zhang, Z. Q., Pan, C. H., & Chung, D. (2011). Tannic acid cross-linked gelatin-gum arabic coacervate microspheres for sustained release of allyl isothiocyanate: Characterization and in vitro release study. *Food Research International*, 44(4), 1000–1007. <https://doi.org/10.1016/j.foodres.2011.02.044>

Zhou, X., Feng, X., Qi, W., Zhang, J., & Chen, L. (2024). Microencapsulation of vitamin E by gelatin-high/low methoxy pectin complex coacervates: Effect of pH, pectin type, and protein/polysaccharide ratio. *Food Hydrocolloids*, 151(December 2023), 109794. <https://doi.org/10.1016/j.foodhyd.2024.109794>

Zhu, H., Zhang, J., Li, C., Liu, S., & Wang, L. (2020). *Morinda citrifolia L.* leaves extracts obtained by traditional and eco-friendly extraction solvents: Relation between phenolic compositions and biological properties by multivariate analysis. *Industrial Crops and Products*, 153(June), 112586.
<https://doi.org/10.1016/j.indcrop.2020.112586>