UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

DAFTAR PUSTAKA

Andriani, D., S, Hadija., dan Hayati, R. 2019. Uji coba pembuatan limbah whey dangke menjadi olahan sorbet. Journal of Tourism, Hospitality, Travel and Business Event, 1(2): 28 - 34.

Ain, N., S, A, Sarah., N, Azmi., A, Bujang., and Ab Mutalib, S. R. 2023. Response surface methodology (RSM) identifies the lowest amount of chicken plasma protein (CPP) in surimi-based products with optimum protein solubility, cohesiveness, and whiteness. CyTA - Journal of Food, 21(1): 646–655.

Abdullah., S, Fatima., dan Suriani. 2021. Uji organoleptik minyak kelapa dalam dengan pemberian ekstrak serai (*Cymbopogon citratus* L.) pada konsentrasi berbeda. Jurnal Pengolahan Pangan, 6(1): 15–19.

Aji, F. M. R., dan Sahubawa, L. 2024. Karakteristik *fish cake* dari surimi lele dumbo (*Clarias gariepinus*) dengan bahan pengikat yang berbeda. Jurnal Pengolahan Hasil Perikanan Indonesia (JPHPI), 27(9): 819–833.

Al-Wraikat, M., Abubaker, M. A., Liu, Y., He, Y., Li, L., and Liu, Y. 2024. Label-free quantitative proteomic analysis of functional changes in goat milk whey proteins subjected to ultra-hightemperature sterilization compared to pasteurization. Food Chemistry, 10 (21): 101691.

AOAC. 2005. Association of Official Analytical Chemist: Official Method of Analysis. Washington, USA: AOA Inc.

Badan Standardisasi Nasional. 2021. Surimi. SNI 2694:2021.

Badan Standardisasi Nasional. 2013. Surimi. SNI 2694:2013.

Badan Standarisasi Nasional 2009. Penentuan mutu pasta pada produk perikanan.

Bachtiar, I., T, W, Agustini., dan Anggo, A, D. 2014. Efektivitas pencucian dan suhu setting (25, 40, 50°C) pada gel kamaboko ikan lele dumbo (*Clarias gariepenus*). Jurnal Pengolahan dan Bioteknologi Hasil Perikanan, 3(4): 45-50.

Bilawal, A., Ishfaq, M., Gantumur, M.-A., Zareen, S., Gankhuyag, J., Hashmi, M. S., Jiang, Z., and Ma, J. 2025. Synergistic effects of ultrasound, pH-shifting and transglutaminase on high internal phase Pickering emulsion stabilized by whey protein isolate microgel particles. International Journal of Biological Macromolecules, 322: 146735.

Benjakul, S., Visessanguan, W., Riebroy, S., Ishizaki, S., and Tanaka. 2004. Gel-forming properties of surimi produced from bigeye snapper, *Priacanthus tayenus* and P *macracanthus*, stored in ice. Journal of the Science of Food and Agriculture, 82(13): 1442-1451.

Buyruk, G., Çelik, M., Küçükgülmez, A., and Kadak, A. E. 2023. The chemical composition, sensory properties, and myofibrillar proteins of surimi produced from tilapia (*Oreochromis niloticus*) meat. Marine Science and Technology Bulletin, 12(3): 402-410.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Cui, H., Yu, J., Xia, S., Duhoranimana, E., Huang, Q., and Zhang, X. 2019. Improved controlled flavor formation during heat-treatment with a stable Maillard reaction intermediate derived from xylose-phenylalanine. Food Chemistry, 271: 47-53.

Chen, M., Huang, X., Lin, Y., and Yi, S. 2025. Vitamin a emulsion encapsulated with whey protein isolate–soybean lecithin enhances surimi gel structure and protein conformation. Foods, 14(20): 3582.

Canti, M., and Martawidjaja, K. L. 2024. Physicochemical and sensory properties of kamaboko produced from Asian seabass surimi–catfish protein isolate *(Clarias gariepinus)*. Measurement: Food, 15: 100184.

Carunchia Whetstine, M. E., Croissant, A. E., and Drake, M. A. 2005. Characterization of dried whey protein concentrate and isolate flavor. Journal of Dairy Science, 88(11): 3826–3839.

Dondero, M., Curotto, E., and Figueroa, V. 2002. Transglutaminase effects on gelation of jack mackerel surimi (*Trachurus murphyi*). Food Science and Technology International, 8(1): 49–54.

Devitria, R., dan Sepriyani, H. 2021. Analisis kadar air dan kadar protein pada surimi ikan patin (*Pangasius* sp.) dengan variasi pencucian dan penambahan tepung sagu. Jurnal Sains dan Kesehatan, 3(1): 19–23.

Dewi, I. K., Wijayanti, I., dan Kurniasih, R. A. 2020. Pengaruh nanokalsium terhadap kekuatan gel kamaboko ikan mujair (*Oreochromis mossambicus*). Agritech, 40(2): 91–101.

Eveline, E., Santoso, J., and Huangdinata, M. 2019. Utilization of Carp (*Cyprinus carpio*) as Surimi for Sausage Manufacturing. Jurnal Pengolahan Hasil Perikanan Indonesia, 22(2): 366–374.

Febiwina, S. D., Irawan, I., Pamungkas, B. F., dan Zuraida, I. 2024. Karakteristik fisikokimia dan penerimaan konsumen terhadap bakso surimi ikan lele sangkuriang (*Clarias gariepinus var. sangkuriang*). Media Teknologi Hasil Perikanan, 12(3): 172–183.

Flory, J., Xiao, R., Li, Y., Dogan, H., Talavera, M. J., and Alavi, S. 2023. Understanding Protein Functionality and Its Impact on Quality of Plant-Based Meat Analogues. Foods, 12(17): 3232.

Fadhlurrohman, I., Andeyani, L., Belvayuna, N., Johan, R. F., Arkan, N. D., Setyawardani, T., and Sumarmono, J. 2025. Pemanfaatan enzim transglutaminase dalam pengembangan produk sosis dari berbagai bahan baku daging: Review. Jurnal Pangan dan Gizi, 15(2): 98–104.

Fang, M., Xiong, S., Hu, Y., Yin, T., and You, J. 2019. In vitro pepsin digestion of silver carp (*Hypophthalmichthys molitrix*) surimi gels after cross-linking by microbial transglutaminase (MTGase). Food Hydrocolloids, 95: 152–160.

Fuchsbauer, H.-L. 2022, Approaching transglutaminase from *Streptomyces* bacteria over three decades. FEBS J, 289: 4680-4703.

Foegeding, E.A. 2015. Food protein functionality. Journal of Food Science, 80: C2670-C2677.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

[FAO] Food and Agriculture Organization. 2024. The State of World Fisheries and Aquaculture 2024: Blue Transformation in Action. Rome: FAO. [diakses 22 Juli 2026].

Fajar, R., Riyadi, P. H., dan Anggo, A. D.2016. Pengaruh kombinasi tepung biji nangka (*Artocarpus heterophyllus* Lamk.) dan tepung tapioka terhadap sifat fisik dan kimia pasta ikan kurisi (*Nemipterus* sp.). Jurnal Pengolahan dan Bioteknologi Hasil Perikanan, 5(4): 59–66.

Guralnick, J. R., Panthi, R. R., Cenini, V. L., Mishra, V. S. N., O'Hagan, B. M. G., Crowley, S. V., and O'Mahony, J. A. 2021. Rehydration properties of whey protein isolate powders containing nanoparticulated proteins. Dairy, 2(4): 602-616.

Guo, G., Li, Y., Du, L., Zhu, S., Cheng, W., Ihsan, A., Zheng, J., and Hu, A. 2025. Whey protein effects on properties and structure of hairtail surimi gel. Food Science and Technology International, 0(0): 1–10.

Gao, X., Xie, Y., Yin, T., Hu, Y., You, J., Xiong, S., and Liu, R. 2021. Effect of high intensity ultrasound on gelation properties of silver carp surimi with different salt contents. Ultrasonics Sonochemistry, 70: 105326.

Gao, Y. L., Yoshida, A., Liu, J. Y., Yuan, J., Maeda, S., Wang, Y., Jiang, Y. R., Sun, X. M., Chen, C. P., Wang, Y., Okajima, T., and Osatomi, K. 2024. Quality improvement of threadfin bream (*Nemipterus virgatus*) surimi-gel using soy protein as a natural food additive. Food Chemistry, 460: 140423.

Gao, Y., Fukushima, H., Deng, S., Jia, R., Osako, K., and Okazaki, E. 2018. Effect of emulsifying stability of myofibrillar protein on the gel properties of emulsified surimi gel. Food Science and Nutrition, 6(5): 1105–1115.

Hidayati, A., dan Sulistiawati, S. 2025. Pengaruh *defatting*, frekuensi pencucian, dan penambahan *cryoprotectants* terhadap mutu surimi ikan patin (*Pangasius hypophthalmus*). Jurnal Harpodon Borneo, 18(2): 1–17.

Huang, P, H., Cheng, Y, T., Hsieh, H, C., Ko, W, C., Lu, W, C., and Li, P, H. 2023. Effects of transglutaminase on the physicochemical properties of surimi and kamaboko prepared by thermal and low level-pressure treatments. Journal LWT, 183: 114863.

Haard, N, F., and Simpson, B, K. 2000. Seafood Enzyme. New York (US): Marcel Dekker, Inc. 147-161p.

Han, G., and Li, Y. 2024. A review of inhibition mechanisms of surimi protein hydrolysis by different exogenous additives and their application in improving surimi gel quality. Food Chemistry, 456 (140002).

Huang, J., Ye, B., and Wang, W. 2021. Incorporation effect of inulin and microbial transglutaminase on the gel properties of silver carp (*Hypophthalmichthys molitrix*) surimi. Food Measure 15: 1–11.

Hamzah, N., Sarbon, N. M., and Amin, A. M. 2015. Physical properties of cobia (*Rachycentron canadum*) surimi: effect of washing cycle at different salt concentrations. Journal of food science and technology, 52(8): 4773–4784.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

He, C., Hu, Y., Woo, M. W., Xiong, H., and Zhao, Q. 2021. Effect of microbial transglutaminase on the structural and rheological characteristics and in vitro digestion of rice glutelin–casein blends. Food Research International, 139: 109832.

Ismail I, Huda N, Ariffin F, and Ismail N. 2010. Effect of washing on the functional properties of duck meat. International Journal of Poultry Science 9(6): 556-561.

Ibrahim, R., Ali, N, A., Mazidi, M, N, I, H., and Lani, M, N. 2023. The quality of surimi from different species of freshwater fish *(Clarias gariepinus, Pangasius hypothalamus, Channa striata and Oreochromis niloticus).* In AIP, 2703: 1-8.

Jafarpour, A., and Gorczyca, E. M. 2012. Contribution of Sarcoplasmic Proteins to Myofibrillar Proteins Gelation. Journal of Food Science, 77(2): 73–81.

Jia, D., Liu, R., Liu, M., Li, Y., & Xiong, S. (2013). Effect of transglutaminase on heat-induced gel properties of bighead carp (*Aristichthys nobilis*) surimi. *Food Science*, 34(9), 37–41.

Jiang, Q., Wu, W., Han, J., Chung, H. Y., Gao, P., Yu, D., Yu, P., Xu, Y., and Xia, W. 2022. Characteristics of silver carp surimi gel under high temperature (≥100 °C): Quality changes, water distribution and protein pattern. International Journal of Food Science & Technology, 57(7): 4613–4627.

Keillor, J. W., Clouthier, C. M., Apperley, K. Y. P., Akbar, A., and Mulani, A. 2014. Acyl transfer mechanisms of tissue transglutaminase. Bioorganic Chemistry, 57: 186–197.

Karthikeyan, M., Shamasundar B, A., Mathew S, Kumar P, R, and Prakash, V. 2004. Physicochemical and functional properties of protein from pelagic fatty fish (*Sardinella longicep*) as function of water washing. International Journal of Food Properties, 7(3): 353-365.

Kementerian Kelautan dan Perikanan. 2024. Statistik KKP produksi perikanan [Data set]. Portal Data KKP RI. Diakses pada 22 Juli 2026, dari https://portaldata.kkp.go.id/datainsight/produksi-ikan-budidaya

Kolotylo, V., Piwowarek, K., and Kieliszek, M. 2023. Microbiological transglutaminase: biotechnological application in the food industry. Open life sciences, 18(1): 20220737.

Kieliszek, M., and Misiewicz, A. 2014. Microbial transglutaminase and its application in the food industry. Polish Journal of Microbiology, 63(3): 241–250.

Laksono, U, T., Suprihatin., Nurhayati, T., dan Romli, M. 2019. Peningkatan kualitas tekstur surimi ikan malong dengan sodium tripolifosfat dan aktivator transglutaminase. Jurnal Pengolahan Hasil Perikanan Indonesia, 22(2): 198-208.

Lanier, T. C., Yongsawatdigul, J., and Carvajal, R. P. 2014. Surimi and Surimi Seafood. Taylor & Francis Group. Boca Raton: CRC Press.

Lin T, M., and Park J, W. 1996. Protein solubility in Pacific whiting affected by proteolysis during storage. J Food Sci, 61(3): 536-539.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Li, Q., Yi, S., Wang, W., Xu, Y., Mi, H., Li, X., and Li, J. 2022. Different thermal treatment methods and TGase addition affect gel quality and flavour characteristics of *Decapterus maruadsi* surimi products. Foods, 11(1): 66.

Li, Q., Wang, H., Lu, J., Yang, M., Zhang, M., Lin, L., and Wang, C. 2025. Microwave-mediated fibrous blended gels of crab meat and surimi: Fibrous protein production method in the perspective of structural remodeling. Innovative Food Science & Emerging Technologies, 100: 103910.

Long, K., T, Zhang., J, W, Park., J, Park. and T, Yin. 2022. Effect of modified washing process on water usage, composition and gelling properties of grass carp surimi. J Sci Food Agric, 102: 7136-7143.

Liang, Y., Jiang, M., Yin, C., Xiao, N., Xia, Q., Yin, Y., and Liu, S. 2025. Coordinated improvement of frozen shrimp surimi gel quality by soybean protein isolate and transglutaminase: The role of building a bridge. Food Research International, 221: 117515.

Makinodan, Y., Nakagawa, T., Ando, M., and Matsuno, S. 1996. Reinforcement of ashi (elasticity) of low salt kamaboko by setting and observation of kamaboko-structure by electron microscope. Nippon Suisan Gakkaishi, 62: 654-658.

Mi, H. B., Zhao, Y. M., Li, Y., Chen, J. X., Liu, H., and Yi, S. M. 2021. Combining effect of soybean protein isolate and transglutaminase on the gel properties of Zhikong scallop (*Chlamys farreri*) adductor muscle. LWT-Food Science & Technology, 8: 138.

Niu, H., Xia, X., Wang, C., Kong, B., and Liu, Q. 2018. Thermal stability and gel quality of myofibrillar protein as affected by soy protein isolates subjected to an acidic pH and mild heating. Food Chemistry, 242: 188–195.

Nicolai, T., Britten, M., and Schmitt, C. 2011. β-lactoglobulin and WPI aggregates: Formation, structure and applications. Food Hydrocolloids, 25(8): 1945–1962.

Nurhayati, T., A, Abdullah., dan T, Hidayat. 2022. The role of pepsin in improving the quality of surimi of red tilapia (*Oreochromis niloticus*). Current Research in Nutrition and Food Science, 10(2): 639–650.

Nugroho, H. C., U, Amalia., dan L, Risaningtyas. 2019. Karakteristik fisiko kimia bakso ikan rucah dengan penambahan transglutaminase pada konsentrasi yang berbeda. Jurnal Ilmu dan Teknologi Perikanan, 1(2): 47–55.

Nurhikma., Serliana., dan Wulandari, D, A. 2024. Karakteristik kimia dan sensori surimi di Perairan Tarakan. Jurnal Ilmu-ilmu Perikanan dan Budidaya Perairan, 19(1): 88-96.

Núñez-Flores, R., D, Cando., A, J, Borderías., and H, M, Moreno. 2018. Importance of salt and temperature in myosin polymerization during surimi gelation. Food Chemistry, 239: 1226–1234.

Ochiai, Y., and Ozawa, H. 2020. Biochemical and physicochemical characteristics of the major muscle proteins from fish and shellfish. Fish Sci, 86: 729–740.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Puri, R., F, Bot., U, Singh., and J, A, O'Mahony. 2021. Influence of transglutaminase crosslinking on casein protein fractionation during low temperature microfiltration. Foods, 10(12): 3146.

Park, J. W. 2005. Surimi and Surimi Seafood. CRS Press, Taylor & Francis Group: 961p.

Park, J. W., and Reed, Z. H. 2014. Seafood Proteins and Surimi. In Z. Ustunol (Ed.), Applied Food Protein Chemistry: 393–425p.

Parapat, C. S., Evnaweri, dan Ratnasari, I. 2021. Kajian sifat fisika kimia hamburger ikan gabus dengan substitusi tepung sukun. Journal of Tropical Fisheries, 16(1): 9–22.

Peng, X., K, Zhao., Y, Li., H, Wang., J, Yu., R, Wen., and H, Zhang. 2024. Effect of whey protein hydrolysate on the structural and functional stability of surimi myofibrillar protein gels during freeze–thaw cycles. International Journal of Biological Macromolecules, 281: 136494.

Putranti, R, T., A, D, Anggo., dan A, S, Fahmihal. 2020. Pengaruh surimi dari ikan swanggi (*Priacanthus* sp.), ikan kurisi (*Nemipterus* sp.), dan ikan kuniran (*Upeneus* sp.) terhadap karakteristik cumi-cumi analog. Jurnal Ilmu dan Teknologi Perikanan, 2(1): 43-53.

Qian, S., Dou, P., Wang, J., Chen, L., Xu, X., Zhou, G., Zhu, B., Ullah, N., and Feng, X. 2021. Effect of MTGase on silver carp myofibrillar protein gelation behavior after peroxidation induced by peroxyl radicals. Food chemistry, 349: 129066.

Ramadhan, H., Aryandi, M. Riva, W. Saputra, dan R. P. Nanda. 2026. Pengujian jumlah pencucian dengan penambahan STPP terhadap nilai organoleptik surimi beku ikan malong. Jurnal Ilmu Perikanan Air Tawar, 6(2).

Ramadhan, K., Huda, N., and Ahmad, R. 2014. Effect of number and washing solutions on functional properties of surimi-like material from duck meat. Journal of food science and technology, 51(2): 256–266.

Radityo, C. T., Darmanto, Y. S., dan Romadhon. 2014. Pengaruh penambahan *egg white powder* dengan konsentrasi 3% terhadap kemampuan pembentukan gel surimi dari berbagai jenis ikan. Jurnal Pengolahan dan Bioteknologi Hasil Perikanan, *3*(4): 1–9.

Ruedt, C., Gibis, M., and Weiss, J. 2023. Meat color and iridescence: Origin, analysis, and approaches to modulation. Comprehensive Reviews in Food Science and Food Safety, 22(4): 3366–3394.

Rozi, A., Khairi, I., Cahyani, R. T., Bija, S., Nurhikma, Wulansari, N., Maulid, D. Y., Utari, S. P. S. D., dan Wulandari, D. A. 2020. Pengaruh defatting, frekuensi pencucian dan penyimpanan beku terhadap kualitas surimi ikan lele. FishtecH, 9(2): 97–106

Ruvinty, A., Devi, N., Warsono E, K.,, dan D, A, P, Paramitha. 2019. Pemanfaatan Microbial Transglutaminase (MTGase) pada Surimi Ikan Patin. Jurnal Ilmu Pangan dan Hasil Pertanian, 3(1): 1-11.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Su, L-X., Chen. J., Liu. J., Shao. Y-H., and Tu. Z-C. 2023. L-lysine modified whey protein isolate: Mechanism on the improvement of the gel properties and its application as model fish sausage. Food Hydrocolloids, 145: 109114.

Sakhawat, Y., Khan, J., Ali, J.S., Shah, S.H.B.U., Malik, Z.I. and Ahmad, A.M.R., 2026. The flavour frontier: Unlocking the secrets of aroma compounds in food science. International Journal of Food Science and Technology, 61(1): 1-17.

Selmi, S., Batista, I., Sadok, S., Bandarra, N, M., and Nunes, M, L. 2008. Chemical composition changes and fat oxidation in sardine mince following sodium bicarbonate and sodium chloride washing. Journal of Food Processing Engineering. 33(2010): 1036-1051.

Saliada, F., Onibala, H., Taher, N., Harikedua, S. D., dan Pandey, E. V. 2017. Karakteristik surimi yang dibuat dari hasil pencucian daging ikan cakalang (*Katsuwonus pelamis* L) dengan air dingin (±4ºC). Media Teknologi Hasil Perikanan, 5(2) 54-57.

Shankar, J.R., and Bansal, G.K., 2013. A Study on health benefits of whey proteins. International Journal of Advanced Biotechnology and Research 4: 15–19.

Sankar, T.V. and Ramachandran, A.(2002, Rheological characteristics of suwari and kamaboko gels made of surimi from Indian major carps. J. Sci. Food Agric., 82: 1021-1027.

Said, M, I., Triatmojo, S., Erwanto, Y., dan Fudholi, A. 2014. Pengaruh perendaman kulit dalam larutan asam asetat terhadap sifat-sifat gelatin berbahan baku kulit kambing bligon. JITP, 3(2): 108–113.

Shi, T., Yuan, L., Kong, Y., Bao, Y., Zhang, H., Lu, C., Jin, W., Monto, A. R., and Gao, R. 2024. Towards higher-quality low salt surimi gels: Significance of the combinatorial effects of chickpea protein with transglutaminase on their micro-structures. LWT, 199: 116103.

Sarie, O. T., Asikin, A. N., dan Kusumaningrum, I. 2018. Pengaruh perbedaan jenis ikan terhadap karakteristik gel surimi. Ziraa'ah Majalah Ilmiah Pertanian, 43(3): 266–272.

Sepriyani, H., R, Devitria., dan Indasari. 2022. Pengaruh pencucian dan penambahan tepung sagu terhadap kadar protein dan lemak surimi ikan patin (*Pangasius* sp.). Jurnal Penelitian Farmasi Indonesia 11(1): 24-27.

Susanti, E., I, S, Setiasih., dan Wulandari, E. 2019. Analisis kekuatan gel surimi ikan lele (*Clarias gariepinus*) hasil ozonasi selama penyimpanan pada suhu 4 ± 1°C. Pasundan Food Technology Journal, 6(2): 91-94.

Saanin, S. T. 1984. Taksonomi dan Kunci Identifikasi Ikan. Jilid I dan II. Penerbit Bina Cipta, Bandung. 250 hal.

Syamsir, S., Naiu, A. S., dan Yusuf, N. 2022. Karakteristik mutu surimi berbagai ikan dari perairan Kota Gorontalo. Jurnal Ilmiah Perikanan dan Kelautan, 10(2): 84–91.

Schmidt S, Adolf F, and Fuchsbauer HL. 2008. The transglutaminase-activating metalloprotease inhibitor from Streptomyces mobaraensis is a glutamine and lysine

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

donor substrate of the intrinsic transglutaminase. Journal FEBS Letters, 582(20): 3132-3138.

Sang, S., Chen, X., Qin, Y., Tong, L., and Ou, C. 2022. A Study on the effects of calcium lactate on the gelling properties of large yellow croaker (*Pseudosciaena crocea*) surimi by low-field nuclear magnetic resonance and raman spectroscopy. *Foods*, *11*(20), 3197.

Somjid, P., Panpipat, W., Cheong, L.-Z., and Chaijan, M. 2021. Reduced washing cycle for sustainable mackerel (*Rastrelliger kanagurta*) surimi production: evaluation of bio-physico-chemical, rheological, and gel-forming properties. Foods, 10(11): 2717

Sitepu, G. S. B., dan Simamora, G. R. R. 2022. Pengaruh penyimpanan beku minced fish dan frekuensi pencucian terhadap kualitas mutu surimi dan kamaboko ikan patin (*Pangasius* sp.). Jambura Fish Processing Journal, 4(2): 52–63.

Suzuki, T. 1981. Fish and Krill Protein: Processing Technology. Netherlands: Springer.

Suryaningrum, T.D., Irianto, H.E., and Ikasari, D. 2015. Characteristics of kamaboko from catfish (*Clarias Gariepinus*) surimi processed with carrot and beet root as filler and natural food colorants. Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology, 10(3): 99-108.

Surilayani, D., Irnawati, R., dan Aditia, R. P. 2019. Mutu surimi ikan gulamah dengan perbedaan frekuensi pencucian. Jurnal Perikanan dan Kelautan, 9(2): 225–234.

Toyohara, H., and Shimizu, Y. 1988. Relation between the modori phenomenon and myosin heavy chain breakdown in threadfin-bream gel. Agricultural and Biological Chemistry, 52(1), 255–257.

Uribe-Alvarez, R., C,P, Murphy., Coleman-Vaughan, C., and O'Shea, N. 2023. Evaluation of ionic calcium and protein concentration on heat- and cold-induced gelation of whey protein isolate gels as a potential food formulation for 3D food printing. Food Hydrocolloids, 142: 108777.

Wati, A.T., dan Intani, E.M. 2021. Penambahan tepung ubi ungu (*Ipomea batatas* L.) terhadap sifat organoleptik dan kimia dalam pembuatan pizza. Jurnal Teknik Pertanian Lampung, 10(4): 488–495.

White, S,S., K, M, Fox., S, M, Jervis., and M,A, Drake. 2012. Influence of heating and acidification on the flavor of whey protei isolate. Journal of Dairy Science, 96(3): 1366-1379.

Wijayanti, I., Romadhon, dan Rianingsih, L. 2015. Karakteristik tekstur dan daya ikat air gel surimi ikan lele (*Clarias batrachus*) dengan penambahan asam tanat dan ekstrak fenol teh teroksidasi. Jurnal Saintek Perikanan, 10(2): 84–90.

Wijayanti, I., Santoso, J., and Jacoeb, A. M. 2012. The Effect of leaching times on the gel properties of catfish (*Clarias gariepinus*) surimi. Saintek Perikanan: Indonesian Journal of Fisheries Science and Technology, 8(1): 32–37.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Wu, M.,Yin, Q., Bian, J., Xu, Y., Gu, C., Jiao, J., Yang, J., and Zhang, Y. 2023. Effects of transglutaminase on myofibrillar protein composite gels with addition of non-meat protein emulsion. Gels, 9 (910): 1-15

Wang, L., Zhang, M., Bhandari, B. and Yang, C. 2018. Investigation on fish surimi gel as promising food material for 3D printing. Journal of Food Engineering, 220: 101-108.

Wang, H., Li, Q., Yang, M., Wang, H., Wang, M., Lin, L., and Lu, J. 2025. High-quality application of crayfish muscle in surimi gels: Fortification of blended gels by transglutaminase. Gels Journal, 11(3): 204.

Wang, Y., Yan, H., Zhuang, Y., Tian, Y., AND Yang, H. 2023. Effect of soy protein isolate, egg white protein and whey protein isolate on the flavor characteristics of silver carp (*Hypophthalmichthys molitrix*) surimi. *LWT, 186*: 115237.

Wijayanti, I., A. Singh., S. Benjakul., and P. Sookchoo. 2021. Textural, sensory, and chemical characteristic of Threadfin Bream (*Nemipterus* sp.) surimi gel fortified with bio-calcium from bone of Asian Sea Bass (*Lates calcarifer*). Foods, 10: 976.

Wasinnitiwong, N., Tavakoli, S., Benjakul, S., dan Hong, H. 2022. Gel properties and protein pattern of threadfin bream (*Nemipterus* spp.) surimi using salted duck egg white powder. Foods (11): 3350.

Wazir, H., Chay, S. Y., Wan Ibadullah, W. Z., Zarei, M., Mustapha, N. A., and Saari, N. 2021. Lipid oxidation and protein co-oxidation in ready-to-eat meat products as affected by temperature, antioxidant, and packaging material during 6 months of storage. RSC Advances, 11(61): 38565–38577.

Wawasto, A., Santoso, J., dan Nurilmala, M. 2018. Karakteristik surimi basah dan kering dari ikan baronang (*Siganus* sp.). Jurnal Pengolahan Hasil Perikanan Indonesia, 21(2): 367-376.

Wicaksana, F, C., Agustini, T, W., dan Rianingsih, L. 2014. Pengaruh penambahan bahan pengikat terhadap karakteristik fisik surimi ikan patin (*Pangasius hypophthalmus*). Jurnal Pengolahan dan Bioteknologi Hasil Perikanan, 3(3):1–8.

Wei, W., Hu, W., and Zhang, X,Y. 2018. Analysis of protein structure changes and quality regulation of surimi during gelation based on infrared spectroscopy and microscopic imaging. Sci Rep 8: 5566.

Wior, J, F, A., Helen, J, Lohoo., Engel, V, Pandey., Netty Salindeho., Josefa T. Kaparang, Daisy M. Makapedua., dan Verly Dotulong. 2020. Mutu Mikrobiologi Produk Surimi Ikan Tuna dan Produk Surimi di Pasar Swalayan. Jurnal Media Teknologi Hasil Perikanan, 8(3): 111–114.

Xie, D., Tang Y., and Dong, G. 2024. Various factors affecting the gel properties of surimi: A review. J Texture Stud, 55(3):e12847.

Yamada, K., Kajita, T., Matsumiya, M., and Fukushima, H. 2018. Evaluation of the quality of frozen surimi using suwari reaction speed and activation energy. CyTA - Journal of Food, *16*(1): 723–729.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Yuliana, I., M, Mahendradratta., and A, Laga. 2020. Identification of the effect of transglutaminase enzyme on physicochemical properties of Milkfish (*Chanos chanos*) surimi gel. Earth and Environmental Science 564 : 1-5.

Yang, M. L., H, Wang., Y, Q, Zhou., J, F, Yin., J, J, Huang., Y, Yan., F, S, Zhang and N, N, Xie. 2024. Novel insights into induced low-salt mandarin fish (*Siniperca chuatsi*) surimi gel with transglutaminase and microwave heating. International Food Research Journal 31(4): 896 – 907.

Yongsawatdigul, L, J., J, W, Park., E, Kolbe., Y, A, Dagga and M,T Morrissey. 1995, Ohmic heating maximizes gel functionality of pacific whiting surimi. Journal of Food Science, 60: 10-14.

Yang, R., N,S, Juma., Y, Zhao., B, Zheng., Y, Xu., Y, Gao., R, Jia., P, Gao and Y, He. 2025. Factors influencing surimi gelling properties and natural additive-based gel fortification strategies: A review. Comprehensive Reviews in Food Science and Food Safety, 24(1):e70067.

Yang, Q., W, Zhou., D, Hu., C, Li., L, Zhang., Y, Zhao., S, Zou., R, Liu., Y, Liu., J, Rong., S, Xiong., and Y, Hu. 2025. Effects of EGCG/TGase on the physicochemical properties and *in vitro* dynamic digestion characteristics of water-saving rinsed surimi gels. Food Chemistry, 493: 145668.

Yunisa, Y., Suhaera, dan S, Sari. 2023. Analisis proksimat bronok (*Acaudina malpadioides*). The Journal General Health and Pharmaceutical Sciences Research, 1(2): 31–40.

Zuraida. I., S, Raharjo., P, Hastuti., and R, Indrati. 2017. Catfish (*Clarias gariepinus*): A potential alternative raw material for surimi production. Pakistan Journal of Nutrition, 16: 928-934.

Zhang, X., Y, Zhang., H, Ding., W, Zhang., and Z, Dai. 2022. Effect of washing times on the quality characteristics and protein oxidation of silver carp surimi. Foods (Basel, Switzerland), 11(16): 2397.

Zhang, L.-D., Liu, Y., Wang, Y.-R., Zhou, T.-Q., Liu, J.-C., Yan, J.-N., Lai, B., Wang, C., and Wu, H.-T. 2025. Gelation melioration of clam *Meretrix meretrix* surimi based on the interactions with different plant/animal proteins. Food Chemistry, 467: 142269.

Zhang, Y., and Chang, S. K. C. 2022. Color and texture of surimi-like gels made of protein isolate extracted from catfish byproducts are improved by washing and adding soy whey. Journal of Food Science, 87(8): 3667–3678.

Zhang, L.-D., Li, L., Zhang, Q., Wang, Y.-Q., Liu, Y., Yan, J.-N., Lai, B., Wang, C., and Wu, H.-T. 2024. Impact of plant and animal proteins with transglutaminase on the gelation properties of clam *Meretrix meretrix* surimi. Food Bioscience, 61: 104915.

Zhao, Q., Zheng, B., Li, J., Cheong, K. L., Li, R., Chen, J. P., Liu, X., Jia, X., Song, B., Wang, Z., and Zhong, S. Y. 2024. Emulsion-filled surimi gel: A promising approach for enhancing gel properties, water holding capacity, and flavor. Trends in Food Science and Technology, 152: 104663.

UNIVERSITAS
GADJAH MADA
Pengaruh Kombinasi Transglutaminase dan Whey Protein Isolate terhadap Mutu Surimi Lele
Gita Putri Pramudyasari Agustina Ramadani, Prof. Dr. Ir. Ustadi, M.P.
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Zhao, X., Mei, T., and Cui, B. 2024. Effect and mechanism of different exogenous biomolecules on the thermal-induced gel properties of surimi: A review. Journal of Food Science, 89: 10266–10282.

Zheng, M., Hong, J., Chuai, P., Chen, Y., Ni, H., Li, Q., and Jiang, Z. 2022. Impacts of agar gum and fucoidan on gel properties of surimi products without phosphate. Food Science and Nutrition, 10: 3759–3771.

Zaitoun, B. J., Palmer, N., and Amamcharla, J. K. 2022. Characterization of a commercial whey protein hydrolysate and its use as a binding agent in the whey protein isolate agglomeration process. Foods (Basel, Switzerland), 11(12): 1797.