

Indonesian engineers, the free nutritious meal program (MBG) needs you!

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Abstract

Indonesia's Free Nutrition Meal Program (*Makan Bergizi Gratis*, MBG), launched in January 2025, is a national social policy designed to improve the nutritional quality of schoolchildren and strengthen social justice. However, in the early stages of implementation, various obstacles such as uneven distribution of services, lack of standard operating procedures, weak supervision, and cases of food poisoning indicate systemic vulnerabilities in kitchen operations. MBG kitchens are not home-scale kitchens, but rather industrial-scale food production facilities that handle perishable food under high time pressure. Therefore, food quality control and safety cannot be adequately addressed through human resource management and training alone but require the integration of engineering into system design and control. In response to these concerns, this editorial calls for the involvement of interdisciplinary engineers to provide evidence-based critique and input on the standardization and sustainability of MBG kitchens. Several engineering needs have been identified, including energy-efficient hot water systems, cold chains, tableware sterilization, ventilation, ergonomic layouts, wastewater management, water recovery, modular kitchens for remote areas, conveyor-based washing automation, and remote process monitoring and recording. In addition, the involvement of engineers and professional associations is essential in formulating and refining evidence-based policies to optimize implementation, while also reducing risks during MBG operations.

Keywords: Free Nutritious Meal Program (MBG); Food safety; Kitchen systems engineering; Energy and water efficiency; Technical audit and standardization

1. Introduction

The Indonesian Free Nutritional Meal Program (*Makan Bergizi Gratis*, MBG) is one of the ambitious national strategic programs in the history of Indonesian social policy [1]. This program is designed to improve the nutritional quality of schoolchildren in order to enhance academic achievement and strengthen social justice through the massive and sustainable provision of nutritious food [2], [3], [4], [5]. With its national scope and enormous scale of operation, the MBG is not simply a social assistance program, but rather an industrial-scale food production and distribution system [6].

However, despite the MBG's strong political legitimacy and budget, its implementation by mid-2025 is still far from expectations, marked by recipient coverage and Nutrition Fulfillment Service Units (*Satuan Pelayanan Pemenuhan Gizi*, SPPG) falling far short of targets, and service quality that has not met public expectations [7]. Key obstacles include an unequal regional distribution, the lack of standardized SOPs, weak field supervision, and the absence of a legal framework guaranteeing universal access to food and food safety [1]. Therefore, the numerous cases of food poisoning that occurred in the field during the early stages of the program indicated serious implementation vulnerabilities [8]. These cases should not be viewed as sporadic incidents or solely due to kitchen staff negligence. Rather, they are an early warning of weak support systems, particularly in areas such as food ingredients, logistics, kitchen infrastructure, sanitation, energy, and waste management.

In the context of a national-scale program, minor technical failures can quickly escalate into public health issues. Based on the author's observations of several MBG kitchens, several engineering deficiencies were identified, related to quality, work efficiency, energy efficiency, and waste management, which contributed to the quality of products and services at the MBG kitchens. Therefore, this editorial calls on Indonesian engineers to address MBG kitchen operational challenges through research and community engagement grounded in appropriate



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technology, and to contribute evidence-based input to public policy formulation. Of course, these considerations are applicable only insofar as the MBG program is assessed and declared suitable for continuation.

1.1. Pros and Cons of the MBG Program

The MBG program has sparked heated debate among the public and academics in Indonesia. Supporters point to global studies on school feeding programs indicating that such initiatives improve children's nutritional status, help reduce food insecurity, and enhance student health and attendance, which in turn may support better academic outcomes and overall well-being [9]. National discussions on the MBG emphasize that ensuring at least one nutritious meal per school day is critical for child development and cognitive performance [10]. The National Nutrition Agency (BGN) also frames the MBG as part of a broader investment in human capital, particularly for children from socioeconomically disadvantaged families [11].

Conversely, the program has attracted substantial criticism. Surveys and opinion pieces highlight public concerns related to effectiveness and governance, including potential budget misuse, operational inefficiencies, and adverse economic effects on local school canteen vendors [12]. Food quality and safety have also been widely debated, with local reports of suspected food poisoning and meals deemed unfit for consumption [13]. Broader critiques further point to issues of financial sustainability, governance capacity, and weak oversight mechanisms in procurement and distribution [14]. While evidence suggests that free or subsidized school lunch programs can deliver meaningful health and educational benefits, the effectiveness of the MBG in Indonesia ultimately depends on robust policy design, transparent governance, and stringent quality control mechanisms to address stakeholder concerns.

1.2. MBG Kitchens Are Not Household-Scale Kitchens

MBG kitchens are not comparable to household kitchens or small catering businesses. They are large-capacity food production facilities with rapid and simultaneous flows of raw materials, cooking processes, distribution, and waste handling. These kitchens handle large quantities of perishable foods such as vegetables, fruits, meat, and eggs under tight time pressure. Under these conditions, food safety cannot be guaranteed through SOPs and human resource training alone. Without well-designed systems, from kitchen layout and material selection to sanitation systems, the risk of cross-contamination remains persistent. When a single point fails, the impact can ripple throughout the entire distribution chain. The perishable nature of food causes every system failure to compound overall risk. Unstable temperatures, inadequate hot water for washing, or poorly managed waste can quickly trigger bacterial growth. At the scale of hundreds or thousands of kitchens, these risks are systemic rather than incidental. Based on monitoring conducted by the Indonesian Education Monitoring Network (*Jaringan Pemantauan Pendidikan Indonesia*, JPPI) indicates that the cumulative number of food poisoning cases linked to the MBG program reached 16,109 individuals as of October 31, 2025 [15].

1.3. Not Just Management, Engineering is Needed

Food poisoning incidents, sanitation problems, energy inefficiency, and failures in waste management share the same root cause: inadequate integration of engineering practices and production governance in large-scale kitchen operations [16], [17]. Too often, MBG kitchen construction prioritizes rapid implementation and administrative compliance over long-term system performance. Standard operating procedures, inspections, and human resource training are important; however, they cannot compensate for fundamental design deficiencies. From an engineering perspective, a poorly designed system will consistently deliver suboptimal performance regardless of operator competence. Neglecting this aspect ultimately jeopardizes the sustainability of the program.

Therefore, MBG kitchens require cross-disciplinary engineering contributions, including mechanical engineers for heating, ventilation, and sanitation systems as well as energy efficiency; environmental engineers for solid waste and wastewater management; industrial engineers for layout design, workflow, and operational efficiency; civil engineers for spatial planning and supporting infrastructure; chemical engineers to address sterilization processes, working fluids, fouling, and waste treatment; and electrical and mechatronics engineers for automation, control, and monitoring systems.

2.A Call to Indonesian Engineers

Indonesia has a large and competent community of engineers, both in higher education and industry. MBG kitchens are a real space for the application of science and innovation that has a direct impact on society. However, this potential has not been optimally utilized. National standards for MBG kitchens are needed that are based on engineering performance, not just administrative requirements. Technical audits must complement managerial audits, so that kitchens are assessed based on their ability to maintain hygiene, energy efficiency, and environmental sustainability. Collaboration between the government, professional associations, and universities can encourage the creation of MBG kitchen models that are safe, efficient, and replicable nationwide. Pilot projects with a strong engineering approach need to be encouraged as proof of concept. Some of the needs identified from the author's observations of MBG kitchens are as follows.

2.1. Energy-Efficient Hot Water Requirements

The MBG kitchen requires a high-temperature, stable supply of hot water to dissolve grease stuck to tableware and cookware. Various studies show that water heating is a significant contributor to energy consumption and commercial kitchen operating costs [18], [19]. The use of low-temperature hot water causes fat residues to remain and increases the risk of microbiological contamination. However, conventional LPG- and electricity-based systems are energy-inefficient and costly to operate, generate greenhouse gas emissions with high global warming potential (GWP) [20], and there have been findings of the use of subsidized 3-kg LPG cylinders for MBG kitchen operations, which is not their intended designation [21]. Therefore, an energy-efficient water heating system based on thermal engineering, such as heat pumps and waste heat utilization, is needed to ensure both cleanliness and energy efficiency. Furthermore, the implementation of solar water heaters can be an environmentally friendly and sustainable solution.

2.2. Cooling and Storage Systems for Perishable Food

Perishable foods such as vegetables, fruits, eggs, and meat require a reliable cold chain to maintain food quality and safety. Inaccurate temperature and humidity control during storage can accelerate quality degradation and increase the risk of contamination [22], [23], [24]. In the context of MBG kitchens, the main challenge is not only “having a refrigerator,” but also ensuring that the cooling system operates stably throughout the day under fluctuating loads, including frequent loading and unloading, high door-opening frequency, and changes in stock volume. Therefore, cold chain design must consider variations in food characteristics, storage capacity, layout configuration, and zone separation to prevent cross-contamination. From an energy perspective, an effective cooling system should incorporate automatic temperature control, straightforward monitoring, and efficiency-enhancing features such as proper insulation, air curtains, or waste heat recovery for hot water production. This engineering-based approach can enhance system resilience, reduce raw material losses, and consistently strengthen food safety performance.

2.3. Tableware Sterilization System

After washing, tableware must be stored in a clean, sterile environment to prevent recontamination before reuse. In MBG kitchens with high production capacity, the risk of recontamination can occur during drying, storage, and distribution, especially in humid environments and busy workflows. Sterilization systems can be chemical-based using food-grade sanitizers, or non-chemical, such as hot steam, UV-C, or ozone [25], [26], [27], [28]. The choice of technology must consider microbial inactivation effectiveness, operator safety, energy availability, and ease of operation so that it can be consistently applied in the field. An engineering approach is needed to ensure that the sterilization process can be validated through measurable parameters (e.g., temperature-time, UV dose, or chemical concentration) so that hygiene quality does not depend on operator habits, but rather on a controlled and auditable system.

2.4. Kitchen Ventilation System for Smoke and Odor Control

Cooking activities in the MBG kitchen produce smoke, water vapor, excess heat, and odors that can reduce air quality in the workspace. An inadequate ventilation system affects operator comfort, increases the risk of health problems, and reduces work safety due to the accumulation

of heat, oil particles, and potential slippery surfaces in the kitchen [29], [30]. In addition, uncontrolled air discharge can cause odor complaints from the surrounding environment, especially in kitchens located near residential areas. Therefore, a mechanical ventilation system is needed that is designed based on air flow and heat transfer analysis, with proper placement of hoods and exhaust ducts, and flow rate control according to production capacity. The design must also ensure that air pressure and flow direction prevent the spread of pollutants to material storage areas or serving rooms. With well-designed ventilation, MBG kitchens become safer, more comfortable, and more environmentally friendly.

2.5. Ergonomic and Efficient Kitchen Design and Layout

A non-ergonomic kitchen layout can lead to time inefficiency, process queues, operator fatigue, and an increased risk of workplace accidents due to overlapping movements and cramped workspaces [31], [32], [33], [34]. In MBG kitchens with high production targets and tight deadlines, an inappropriate design will result in motion waste, longer service times, and an increased chance of cross-contamination due to the intersection of raw materials, cooked food, and waste. Therefore, the design of an MBG kitchen must consider the overall workflow, from raw material reception, washing, preparation, cooking, packaging, to distribution, with clear zone separation and minimal backtracking. The design also needs to consider ergonomic aspects such as workbench height, reach distance, lifting loads, and safety in hot and wet areas. An ergonomic and systems engineering approach is necessary for the kitchen to maintain consistently high productivity while protecting operators from fatigue and long-term occupational risks.

2.6. Liquid Waste Management

MBG kitchen wastewater generally contains fats, oils, food scraps, and detergents that have the potential to pollute the environment if discharged directly into public sewers. Without preliminary treatment, fats, oils, and grease (FOG) can cause pipe blockages, odors, and increased pollution loads on the drainage system [35], [36]. In addition to its ecological impact, this condition also risks causing public complaints and problems with compliance with environmental quality standards. Therefore, a liquid waste management system needs to be designed as part of the kitchen infrastructure, not just an addition. An ideal system includes fat separation through a grease trap or FOG separator unit, initial sedimentation for solids, and a simple treatment stage before discharge into the environment. An engineering approach is needed to ensure consistent processes through measurable parameters such as flow rate, temperature, pH, and organic load indicators. With proper design, MBG kitchens can reduce pollution risks, maintain operational smoothness, and enhance long-term service sustainability.

2.7. Water Recovery for Water Use Efficiency

Water consumption in the MBG kitchen is relatively high, especially for washing tableware, cooking utensils, and cleaning the work area. If not managed, high water usage will increase operational costs and add to the volume of liquid waste that must be treated. Therefore, the recovery and reuse of certain types of water can be an efficiency strategy [37], especially for the pre-washing or initial cleaning stages that do not require water quality equivalent to clean drinking water. However, the implementation of water reuse cannot be done carelessly because it is directly related to hygiene and food safety. Water recovery systems require an engineering approach involving multi-stage filtration to separate solids, reduce organic load, and routine monitoring of water quality through simple parameters (e.g., turbidity, odor, pH, and contamination indicators).

2.8. Modular Kitchen Prototype for Remote Areas

Remote areas face unique challenges in implementing MBG kitchens, ranging from limited energy and water infrastructure, difficult logistical access, to the availability of trained human resources that are not always adequate. These conditions make the conventional kitchen construction approach often ineffective, slow, and expensive, requiring a more adaptive and quickly implemented solution. One strategic option is the development of modular buildings that are engineered to be installed quickly, flexible to local conditions, and easy to replicate in multiple locations [38], [39]. Modular kitchen prototypes need to consider ease of transportation (e.g., knock-down or container systems), ease of assembly with simple tools, and designs that are resistant to local environments such as high humidity, extreme temperatures, or coastal

conditions. In addition, the design must also integrate critical aspects such as the cold chain, hot water supply, sanitation, and waste management in a compact yet safe configuration. With this approach, MBG service standards in remote areas can be more in line with urban areas, while accelerating the equitable distribution of nutrition access nationwide.

2.9. Conveyor-Based Automatic Washing Equipment

Manual washing often makes it difficult to ensure consistent cleanliness in MBG kitchens that serve hundreds to thousands of meals per day. In addition to relying on the skills and discipline of operators, manual processes tend to be time-consuming, require a lot of water, and risk causing work queues during peak hours. Therefore, conveyor-based automatic washing equipment can be a solution to improve hygiene, speed up the process, and reduce operator fatigue through a more standardized and repetitive workflow [40]. This system allows washing to take place in several controlled stages, such as pre-rinsing, washing with detergent, final rinsing with hot water, and drying. To work optimally, it requires the integration of mechanical engineering (conveyor design, nozzles, and corrosion-resistant materials), thermal engineering (efficient and stable water heating), and an automatic control system to maintain temperature, contact time, and water discharge. In MBG implementation, the design can be developed in two forms: a fixed configuration for large kitchens, and a portable configuration for temporary kitchens or areas with infrastructure limitations. With proper automation, the washing process becomes faster, more consistent, and easier to audit as part of the food safety system.

2.10. Remote Process Monitoring and Recording System

Remote monitoring enables real-time supervision of MBG kitchen performance without having to rely on manual inspections in the field. Critical parameters such as food storage temperature, hot water temperature for washing, daily energy consumption, kitchen air quality, and sterilization process indicators can be monitored continuously to ensure that operational conditions remain within safe limits [41], [42]. With this system, potential deviations can be detected early before they develop into food safety issues or service disruptions. In addition to monitoring, data logging plays an important role as the basis for technical audits and continuous improvement. Historical data enables evidence-based evaluation, such as trends in cold storage temperature fluctuations, energy waste patterns, or inconsistencies in the sanitation process at certain hours. An engineering approach is needed to design reliable sensor systems, interfaces that are easy for operators to understand, and simple yet effective alert mechanisms. With the implementation of monitoring and data logging, MBG kitchen operational standards can be maintained more consistently across various locations, while strengthening accountability and service quality nationwide.

2.11. Evidence Based Policy Formulation

Beyond technical design and operational interventions, engineers should be institutionally involved in the formulation of policies related to MBG. Recurrent problems observed in MBG kitchens, including food poisoning incidents, uneven service quality, energy inefficiency, logistical issues, and environmental risks, are not merely implementation challenges but symptoms of policies lacking a strong technical foundation. Policies developed without systematic technical input tend to prioritize administrative compliance over system performance, risk control, and long-term sustainability. Engineers possess the analytical capacity to translate on-site technical realities into measurable, verifiable, and enforceable policy instruments, such as performance-based standards for temperature stability, sanitation effectiveness, ventilation capacity, energy intensity, and wastewater discharge quality. Through system modeling, pilot testing, and technoeconomic analysis, engineers can assist policymakers in evaluating trade-offs between cost, scalability, safety, and environmental impacts before national implementation. This evidence-based approach can reduce large-scale policy errors and minimize unintended consequences that may compromise public health or erode public trust [43]. To enable such contributions, formal mechanisms are required to integrate engineers into regulatory development teams, standards-setting committees, and strategic policy forums related to MBG. Accordingly, professional associations, universities, and research institutions should be positioned not only as implementers or evaluators, but also as strategic partners in policy formulation.

3. Conclusion

The success of MBG as a national strategic program is determined not only by adequate budgeting and managerial readiness, but also by the resilience of the technical kitchen system as the core of large-scale daily food production. The numerous poisoning cases and operational issues observed during the early stages of implementation should be understood as indicators of weak supporting systems rather than merely the failure of individual operators. At the scale of hundreds to thousands of kitchens, variables such as storage temperature stability, hot water availability, sterilization effectiveness, ventilation, workflow ergonomics, energy efficiency, and waste management play a decisive role in ensuring food safety and consistent service quality.

Therefore, MBG requires the systematic integration of interdisciplinary engineering expertise and the adoption of technically auditable, performance-based standards. Collaboration among government agencies, universities, industry, and professional associations is essential to support prototype development, appropriate technological innovation, data-driven monitoring systems, and evidence-based policy formulation. In this context, MBG kitchens also represent a significant academic research domain spanning energy systems, sanitation, ergonomics, environmental engineering, automation, and performance-based policy design. Without strong engineering contributions, MBG-related challenges will continue to manifest as systemic failures rather than isolated incidents.

Authors' Declaration

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References

- [1] S. Rasanjani and I. Rahmi, "Free School Meals Policy: Lessons Learned from Around the World for Indonesia," *Jurnal Ilmu Sosial*, vol. 24, no. 1, pp. 1–28, 2025, doi: 10.14710/jis.24.1.2025.1-28.
- [2] M. N. Abadi *et al.*, "Unraveling Future Trends in Free School Lunch and Nutrition: Global Insights for Indonesia from Bibliometric Approach and Critical Review," 2025. doi: 10.3390/nu17172777.
- [3] F. P. Julian and A. K. Pranata, "The Sustainability Principles in the Nutritious Meal Program: A Study of Environmental Law and Popular Economy Aspects," in *IOP Conference Series: Earth and Environmental Science*, 2025. doi: 10.1088/1755-1315/1537/1/012024.
- [4] C. Thawley, M. Crystallin, and K. Verico, "Towards a Higher Growth Path for Indonesia," *Bulletin of Indonesian Economic Studies*, vol. 60, no. 3, pp. 247–282, 2024, doi: 10.1080/00074918.2024.2432035.
- [5] R. I. Soma, A. Azhar, and T. Uchiyama, "Food preferences in Indonesian schoolchildren and the parents' perspectives on the upcoming nutritious free meal program," in *E3S Web of Conferences*, 2024. doi: 10.1051/e3sconf/202457702004.
- [6] D. Sukmasari, S. Aritonang, A. Sudiarso, and K. Pujiyanto, "Optimization of Free Nutritious Meal Supply Chain Program in Support of Indonesia ' s Non-Military Defense Force," *Jurnal Ilmiah Global Education*, vol. 6, no. 3, pp. 2202–2209, 2025, doi: 10.55681/jige.v6i3.4195.
- [7] M. W. Askar *et al.*, "Makan (Tidak) Bergizi (Tidak) Gratis," Jakarta, 2025. [Online]. Available: https://celios.co.id/wp-content/uploads/2025/12/Makan-Tidak-Bergizi-Tidak-Gratis_CELIOS_Biru_Baru_16-des.pdf
- [8] F. A. Suprpto, E. Praditya, R. M. Dewi, and W. Adiyoso, "A Policy Implementation Review of the Free Nutritious Meal (MBG) Program," *The Journal of Indonesia Sustainable Development Planning*, vol. 6, no. 2, pp. 297–312, 2025, doi: 10.46456/jisdep.v6i2.798.
- [9] A. Cupertino, V. Ginani, A. P. Cupertino, and R. B. A. Botelho, "School Feeding Programs: What Happens Globally?," *International journal of environmental research and public health*, vol. 19, no. 4, Feb. 2022, doi: 10.3390/ijerph19042265.

- [10] B. Suwastoyo, "Dilema Program Makan Siang Gratis, Antara Manfaat dan Tantangan," CIPS: Center for Indonesian Policy Studies. Accessed: Feb. 02, 2026. [Online]. Available: <https://www.cips-indonesia.org/post/dilema-program-makan-siang-gratis-antara-manfaat-dan-tantangan?>
- [11] BGN, "Kepala BGN Respon Pro Kontra Program MBG: Ini Investasi Jangka Panjang Perbaiki Kualitas SDM," <https://www.bgn.go.id/>. Accessed: Feb. 02, 2026. [Online]. Available: <https://www.bgn.go.id/news/siaran-pers/kepala-bgn-respon-pro-kontra-program-mbg-ini-investasi-jangka-panjang-perbaiki-kualitas-sdm?>
- [12] Z. V. A. Hakim, "Pro Kontra Program Makan Bergizi Gratis: Kualitas Makanan dan Dampak Ekonomi Jadi Sorotan," <https://portalhukum.id/>. Accessed: Feb. 02, 2026. [Online]. Available: <https://portalhukum.id/politik-hukum/pro-kontra-program-makan-bergizi-gratis-kualitas-makanan-dan-dampak-ekonomi-jadi-sorotan/>
- [13] I. A. Achmad, E. Emirati, and J. Basra, "Polemik Program Makan Bergizi Gratis (MBG) Dan Kesenjangan Akses Pada Sekolah Nonformal: Studi Kasus PKBM Dalam Program Paket A," *Jurnal Ilmiah Multidisiplin Mahasiswa dan Akademisi*, vol. 1, no. 4, pp. 24–32, 2025, doi: 10.64690/intelektual.v1i4.318.
- [14] A. Lestari, "CISDI Kritik MBG: Anggaran Membengkak Tanpa Regulasi dan Tata Kelola yang Jelas," <https://islam.nu.or.id/>. Accessed: Feb. 02, 2026. [Online]. Available: <https://islam.nu.or.id/nasional/cisdi-kritik-mbg-anggaran-membengkak-tanpa-regulasi-dan-tata-kelola-yang-jelas-1yDCn>
- [15] A. Ridwan, "MBG Poisoning Victims Reach 16,000 by End of October 2025, Here's the Provincial Distribution," <https://databoks.katadata.co.id/>. Accessed: Feb. 02, 2026. [Online]. Available: <https://databoks.katadata.co.id/en/demographics/statistics/690ad30e230b1/mbg-poisoning-victims-reach-16000-by-end-of-october-2025-heres-the-provincial-distribution>
- [16] S. Rodgers, "Food service research: An integrated approach," *International Journal of Hospitality Management*, vol. 30, no. 2, pp. 477–483, 2011, doi: <https://doi.org/10.1016/j.ijhm.2010.05.002>.
- [17] N. Chandimali, J. Bae, J. Y. Hwang, S. G. Bak, S. H. Cheong, and S. J. Lee, "Integrated Hygiene Control Strategies in Food Manufacturing: Technologies, Regulations, and Socioeconomic Impacts," *Journal of Food Protection*, vol. 88, no. 7, p. 100547, 2025, doi: <https://doi.org/10.1016/j.jfp.2025.100547>.
- [18] L. Pereira, V. Aguiar, and F. Vasconcelos, "FIKWATER: A Water Consumption Dataset from Three Restaurant Kitchens in Portugal," 2021. doi: 10.3390/data6030026.
- [19] J. Spriet, A. P. Singh, B. Considine, M. K. Murali, and A. McNabola, "Design and Long-Term Performance of a Pilot Wastewater Heat Recovery System in a Commercial Kitchen in the Tourism Sector," 2023. doi: 10.3390/w15203646.
- [20] L. A. Omeiza *et al.*, "Application of solar thermal collectors for energy consumption in public buildings – An updated technical review," *Journal of Engineering Research (Kuwait)*, vol. 12, no. 4, pp. 994–1010, 2024, doi: 10.1016/j.jer.2023.09.011.
- [21] B. A. Priyantomo, "Critical Discourse Analysis of Free Nutritious Meal Policy : A Study Social Media X," in *International Conference Proceedings Universitas Islam Balitar*, Blitar: Universitas Islam Blitar, 2025, pp. 459–482.
- [22] D. I. Onwude, G. Chen, N. Eke-Emezies, A. Kabutey, A. Y. Khaled, and B. Sturm, "Recent advances in reducing food losses in the supply chain of fresh agricultural produce," *Processes*, vol. 8, no. 11, pp. 1–31, 2020, doi: 10.3390/pr8111431.
- [23] M. M. Aung and Y. S. Chang, "Temperature management for the quality assurance of a perishable food supply chain," *Food Control*, vol. 40, no. 1, pp. 198–207, 2014, doi: 10.1016/j.foodcont.2013.11.016.
- [24] W. A. Spagnol, V. Silveira, E. Pereira, and N. G. Filho, "Monitoring the cold chain: New technologies and recent advances," *Brazilian Journal of Food Technology*, vol. 21, pp. 2–8, 2018, doi: 10.1590/1981-6723.6916.
- [25] M. L. Rochman *et al.*, "Design and Implementation of Sterilization Chamber with Ozone and UV-C Light to Break the Transmission of Covid-19," *Urecol Journal.Part D: Applied Sciences*, vol. 1, no. 2, pp. 41–49, 2021, doi: 10.53017/ujas.55.

- [26] R. S. Chavan, M. Ansari, and S. Bhatt, "Packaging: Aseptic Filling," in *Encyclopedia of Food and Health*, 2015, pp. 191–198. doi: 10.1016/B978-0-12-384947-2.00512-2.
- [27] C. Y. Kim, G. J. Ryu, H. Y. Park, and K. Ryu, "Resistance of *Staphylococcus aureus* on food contact surfaces with different surface characteristics to chemical sanitizers," *Journal of Food Safety*, vol. 37, no. 4, 2017, doi: 10.1111/jfs.12354.
- [28] S.-S. Kim, S.-H. Kim, S.-H. Park, and D.-H. Kang, "Inactivation of *Bacillus cereus* spores on stainless steel by combined superheated steam and UV-C irradiation treatment," *Journal of Food Protection*, vol. 83, no. 1, pp. 13–16, 2020, doi: 10.4315/0362-028X.JFP-19-133.
- [29] K. Hanvey, "Occupational Exposure To Cooking Emissions And Evaluation Of Ventilation System In Restaurant Kitchens," 2025, *The University of Alabama at Birmingham*.
- [30] M. T. E. Kulve, M. Loomans, A. Boerstra, and D. Schrock, "Exploring PM2.5 Exposure of Chefs in Professional Kitchens," *ASHRAE Journal*, vol. 64, no. 9, pp. 16–26, 2022.
- [31] S. M. Vadivel, P. Suganya, C. Devanathan, A. H. Sequeira, and A. Abhinav, "Modular Kitchen Layout Design Using AHP Method – An Indian Case Perspective," in *Lecture Notes in Networks and Systems*, 2024, pp. 348–357. doi: 10.1007/978-3-031-64850-2_33.
- [32] T. Shimmura, N. Fujii, and T. Kaihara, "Staff Motion Reduction at a Japanese Restaurant by Kitchen Layout Redesign after Kitchen Simulation," in *Procedia CIRP*, 2017, pp. 106–110. doi: 10.1016/j.procir.2016.07.007.
- [33] A. Bhatia, S. Singla, and A. Bansal, "Ergonomic Analysis on Kitchen Using Asian Manikin," in *Lecture Notes in Networks and Systems*, 2023, pp. 428–437. doi: 10.1007/978-3-031-50151-7_41.
- [34] M. A. Gumasing and K. D. Lustañas, "Predictive model on the severity of injuries and musculoskeletal disorders affecting the restaurant kitchen workers in the Philippines," in *Proceedings of the International Conference on Industrial Engineering and Operations Management*, 2021, pp. 2607–2616.
- [35] E. Nieuwenhuis, J. Langeveld, and F. Clemens, "The relationship between fat, oil and grease (FOG) deposits in building drainage systems and FOG disposal patterns," *Water Science and Technology*, vol. 77, no. 10, pp. 2388–2396, 2018, doi: 10.2166/wst.2018.173.
- [36] M. Omidvar, M. R. Malayeri, F. Farshchi Tabrizi, and M. M. Doroodmand, "Investigation of used cooking oil on the formation of FOG deposits in sewer line clogging," *Environmental Science and Pollution Research*, vol. 30, no. 7, pp. 18325–18339, 2023, doi: 10.1007/s11356-022-23480-0.
- [37] S. Veluru, H. T. Hamzah, G. Gudapati, J. V Varma, S. Nikhil, and M. Musalaiah, "Water reuse and recycling in the circular economy," in *Water Use Efficiency, Sustainability and The Circular Economy*, 2025, pp. 1–15. doi: 10.1016/B978-0-443-26749-9.00008-9.
- [38] M. Zohourian, A. Pamidimukkala, S. Kermanshachi, and D. Almaskati, "Modular Construction: A Comprehensive Review," *Buildings*, vol. 15, no. 12, 2025, doi: 10.3390/buildings15122020.
- [39] W. Ferdous, A. Manalo, A. Sharda, Y. Bai, T. D. Ngo, and P. Mendis, "Construction Industry Transformation Through Modular Methods," in *Innovation in Construction: a Practical Guide to Transforming the Construction Industry*, 2022, pp. 259–276. doi: 10.1007/978-3-030-95798-8_11.
- [40] M. Shahid, U. Hayyat, M. Usman, D. Ahmad, A. Asghar, and A. Waleed, "Design and Fabrication of Low Cost, Time Saving, Automatic Dishwasher with Water Recycling Feature," in *2023 International Conference on IT and Industrial Technologies, ICIT 2023*, 2023. doi: 10.1109/ICIT59216.2023.10335703.
- [41] K. Gurunathan, "Time–Temperature Indicators (TTIs) for Monitoring Food Quality," in *Smart Food Packaging Systems: Smart Food Packaging Systems*, 2024, pp. 281–304. doi: 10.1002/9781394189595.ch11.
- [42] T. Gao, Y. Tian, Z. Zhu, and D.-W. Sun, "Modelling, responses and applications of time-temperature indicators (TTIs) in monitoring fresh food quality," *Trends in Food Science and Technology*, vol. 99, pp. 311–322, 2020, doi: 10.1016/j.tifs.2020.02.019.
- [43] OECD, "Scientific Advice for Policy Making: The Role and Responsibility of Expert Bodies and Individual Scientists," *OECD Science, Technology and Industry Policy Papers*, no. 21, 2015, doi: 10.1787/5js3311jcpwb-en.