Journal of Food and Agricultural Product
Vol. 6 No. 1 Tahun 2026
e-ISSN 2807-8446
http://journal.univetbantara.ac.id/index.php/jfap

Peran Teknologi Produksi Bersih pada Industri Pangan di Indonesia dalam Peningkatan Kualitas Hasil Produk: Tinjauan Singkat

[The Role of Cleaner Production Technology in Indonesia's Food Industry in Improving Product Quality: A Mini Review]

Nurul Izzah Aulia[1], Fatria Resti Haryani[1], Onne Akbar Nur Ichsan[2], dan Syifa' Robbani[1]

[1] Program Studi Teknik Pertanian, Fakultas Pertanian, Universitas Sriwijaya, Jl Raya Palembang Prabumulih Km. 32 Inderalaya Ogan Komering Ilir, Kab. Ogan Ilir, Sumatera Selatan
[2] Program Studi Teknologi Hasil Pertanian, Fakultas Pertanian, Universitas Sriwijaya, Jl Raya Palembang Prabumulih Km. 32 Inderalaya Ogan Komering Ilir, Kab. Ogan Ilir, Sumatera Selatan

* Email korespondensi : nurulizzaha@fp.unsri.ac.id

ABSTRACT

The food industry in Indonesia faces challenges in improving product quality in line with demands for environmental sustainability and resource efficiency. Clean Production Technology (CPT) is a strategic approach that integrates pollution prevention, energy efficiency, and optimization of raw material use in food production processes. This study aims to briefly review the role and contribution of clean production technology in improving the quality of food industry products in Indonesia. The method used is a literature review of various scientific publications, institutional reports, and policies related to the application of CPP in the food sector. The review results show that the application of clean production technology, such as waste minimization, reuse of by-products, energy and water efficiency, and the application of environmentally friendly process technology, contributes positively to improving product quality, food safety, and quality consistency. In addition, TPB also supports the improvement of the food industry's competitiveness through reduced production costs and an improved corporate environmental image. However, the implementation of TPB in Indonesia still faces obstacles in the form of technological limitations, initial investment, and low awareness and capacity of human resources. Therefore, synergy between industry players, government, and academics is needed to strengthen the sustainable adoption of clean production technology. The results of this study are expected to be an initial reference in the development of policies and strategies for the application of TPB in the national food industry.

Keywords: Resource efficiency, food industry, environmental sustainability, product quality, clean production technology

ABSTRAK

Industri pangan di Indonesia menghadapi tantangan dalam meningkatkan kualitas produk seiring dengan tuntutan keberlanjutan lingkungan dan efisiensi sumber daya. Teknologi Produksi Bersih (TPB) menjadi pendekatan strategis yang mengintegrasikan upaya pencegahan pencemaran, efisiensi energi, serta optimalisasi penggunaan bahan baku dalam proses produksi pangan. Penelitian ini bertujuan untuk meninjau secara singkat peran dan kontribusi teknologi produksi bersih dalam meningkatkan kualitas hasil produk industri pangan di Indonesia. Metode yang digunakan adalah tinjauan literatur terhadap berbagai publikasi ilmiah, laporan institusi, dan kebijakan terkait penerapan TPB pada sektor pangan. Hasil tinjauan menunjukkan bahwa penerapan teknologi produksi bersih, seperti minimisasi limbah, pemanfaatan kembali hasil samping, efisiensi energi dan air, serta penerapan teknologi proses yang ramah lingkungan, berkontribusi positif terhadap peningkatan mutu produk, keamanan pangan, dan konsistensi kualitas. Selain itu, TPB juga mendukung peningkatan daya saing industri pangan melalui penurunan biaya produksi dan peningkatan citra lingkungan perusahaan. Namun, implementasi TPB di Indonesia masih menghadapi kendala berupa keterbatasan teknologi, investasi awal, serta rendahnya kesadaran dan kapasitas sumber daya manusia. Oleh karena itu, diperlukan sinergi antara pelaku industri, pemerintah, dan akademisi untuk

memperkuat adopsi teknologi produksi bersih secara berkelanjutan. Hasil penelitian ini diharapkan dapat menjadi referensi awal dalam pengembangan kebijakan dan strategi penerapan TPB pada industri pangan nasional..

Kata kunci: Efisiensi sumber daya, industri pangan, keberlanjutan lingkungan, kualitas produk, teknologi produksi bersih

Introduction

The food industry is one of the strategic sectors in Indonesia's economic development because it contributes significantly to food security, value addition of agricultural commodities, and employment generation (Azalia et al., 2020). However, the competitiveness of the food industry is no longer determined only by production capacity and market reach, but also by its ability to consistently deliver products that are safe, high in quality, and produced through sustainable processes. Increasing consumer awareness, stricter global market requirements, and growing environmental pressures have shifted industrial priorities from end-product inspection toward process-based quality assurance and sustainability-oriented production systems (Varzakas & Smaoui, 2024; Ammar et al., 2020).

In the food sector, product quality is closely associated with the effectiveness of process control, sanitation, hazard prevention, and resource efficiency throughout the production chain. Good Manufacturing Practices (GMP) provide the fundamental operational conditions required to maintain hygiene and process discipline, while Hazard Analysis and Critical Control Points (HACCP) function as a preventive food safety system that identifies and controls critical hazards during processing. In parallel, Cleaner Production Technology (CPT) emphasizes preventive technological and managerial strategies to reduce waste generation, optimize the use of water and energy, improve process efficiency, and minimize environmental impacts at the source. Therefore, CPT, GMP, and HACCP should not be viewed as separate approaches; rather, they are conceptually interconnected. GMP establishes the basic production environment, HACCP ensures the control of food safety hazards, and CPT strengthens process efficiency and sustainability, all of which may ultimately influence product quality.

Recent studies have shown that cleaner production and green manufacturing practices can improve operational efficiency and corporate sustainability performance (Afum et al., 2020). In food processing, environmentally oriented technologies such as energy-efficient equipment, thermal process optimization, by-product utilization, and circular waste management have also been reported to reduce material losses and improve consistency in processing outcomes (Lisboa et al., 2024; Pokharel et al., 2023). Nevertheless, most previous studies have primarily examined cleaner production from the perspectives of environmental performance, cost reduction, or resource efficiency. In contrast, relatively limited attention has been given to how cleaner production strategies may directly influence food product quality parameters, including physicochemical attributes such as pH, moisture content, water activity, texture, color stability, oxidation stability, and nutrient retention; microbiological aspects such as total microbial load, yeast and mold contamination, and pathogen control; as well as quality consistency reflected in sensory uniformity, shelf-life stability, and batch-to-batch consistency.

This condition indicates an important research gap, particularly in the Indonesian food industry context. Although the literature acknowledges that sustainable production practices can indirectly affect product quality, there is still limited review-based evidence that explicitly connects Cleaner Production Technology with measurable quality improvement outcomes in food products (Rumanti et al., 2020; Suryaningrat et al., 2020). More specifically, the relationship between CPT implementation and improvements in physicochemical stability, microbiological safety, sensory consistency, shelf-life performance, and process reliability has not been comprehensively synthesized. In addition, the conceptual linkage between CPT and established quality assurance systems such as GMP and HACCP remains underexplored in existing review studies. As a result, the strategic role of CPT in strengthening both sustainability and food quality has not yet been clearly articulated.

Based on this gap, this review aims to examine the role of Cleaner Production Technology in improving product quality in the Indonesian food industry. The novelty of this review lies in its attempt to position CPT not only as an environmental management approach, but also as a process-based strategy that complements GMP and HACCP in achieving higher and more consistent food quality. By synthesizing studies published over the last 15 years, this review analyzes how cleaner production practices influence process efficiency, waste reduction, parameter control, and specific product quality outcomes, including physicochemical properties, microbiological safety, sensory consistency, and shelf-life stability. The findings are expected to contribute to a clearer conceptual understanding of the relationship between sustainable production and food quality, while also providing practical insights for industrial implementation, policy development, and future research in Indonesia.

Method

This study employed a systematic literature review (SLR) to identify, select, evaluate, and synthesize relevant studies on the role of Cleaner Production Technology (CPT) in improving product quality in the Indonesian food industry. The review covered scientific articles, conference proceedings, technical reports, and policy documents published between 2010 and 2025. Literature sources were obtained from several major databases, including Scopus, ScienceDirect, SpringerLink, and Google Scholar.

The review process was carried out through several stages. First, the study objectives and review questions were defined to clarify the scope of the review, particularly regarding the forms of CPT implementation in the food industry and their relationship with product quality improvement. Second, a search protocol was developed by determining the databases, publication period, document types, and search keywords. The main keywords included “cleaner production,” “green manufacturing,” “food industry,” “food quality,” and “Indonesia,” which were combined using Boolean operators such as AND and OR to broaden or refine the search results.

Third, the identification stage was conducted by collecting all potentially relevant publications from the selected databases. Fourth, the screening stage was performed by reviewing titles, abstracts, and keywords to exclude documents that were not relevant to the topic. At this stage, duplicate records and publications unrelated to the Indonesian food industry, cleaner production practices, or product quality were removed. Fifth, the eligibility stage involved a full-text review of the remaining articles to determine whether they met the inclusion criteria. The inclusion criteria were: (1) studies

discussing the application of CPT or related environmentally friendly production practices in the food industry; (2) studies conducted in, or relevant to, the Indonesian context; and (3) studies reporting implications for product quality, such as physicochemical characteristics, microbiological safety, sensory consistency, or shelf-life stability. Publications with insufficient methodological information or without clear relevance to the review objective were excluded.

After the selection process, the eligible studies were subjected to data extraction using a structured worksheet. The extracted information included the authors, publication year, study location, type of food industry, type of CPT application, production aspects improved, and product quality indicators reported.

The extracted data were then analyzed using a descriptive and narrative synthesis approach. The analysis focused on identifying patterns of CPT implementation, the mechanisms through which CPT influenced product quality, the dominant quality parameters assessed in previous studies, and the remaining research gaps. The results of the review were finally organized and presented narratively to explain the strategic role of Cleaner Production Technology in supporting both sustainability and product quality improvement in the Indonesian food industry.

Discussion

Cleaner Production Technology in Indonesia's Food Industry

Clean production is a strategic approach to industrial environmental management that emphasizes the principle of pollution prevention from the planning and design stages of the process (Aulia et al., 2024). In the Indonesian context, this concept is becoming increasingly relevant as pressure mounts on the food industry to meet food safety standards, resource efficiency, and compliance with national environmental regulations (Ministry of Environment, 2018). The Indonesian government, through its green industry and circular economy policies, is encouraging the transformation of production processes to be more efficient and environmentally friendly, especially in the agro-based manufacturing sector, which contributes significantly to the national GDP. Clean production is positioned as part of a sustainable manufacturing framework that integrates energy efficiency, water conservation, and waste minimization into production systems (Giannetti et al., 2020).

In the Indonesian food industry, the implementation of clean production is of high urgency due to the characteristics of its processes, which are intensive in their use of water, energy, and agricultural raw materials. Agricultural processing industries such as palm oil, fisheries, dairy, and flour-based products generate large amounts of liquid and solid waste if not managed preventively (Abuzar et al., 2023). Recent studies show that the application of environmentally friendly food processing technologies, such as thermal process optimization, utilization of by-products, and process water recycling systems, can improve efficiency while maintaining product quality stability (Nadya et al., 2020). This approach also contributes to increasing the competitiveness of Indonesian food products in export markets that are increasingly strict on sustainability standards.

However, the implementation of clean production in the national food industry still faces various obstacles, particularly in the small and medium-sized industry (IKM) sector (Neto et al., 2022). Limited access to modern technology, relatively high initial investment, and low technical literacy regarding process efficiency are the main barriers to the adoption of clean technology (Pakravan & MacCarty, 2020). In addition, most industry players still apply an end-of-pipe treatment approach, which is reactive and does not address the root cause of production efficiency issues. In fact,

preventive strategies through clean production have proven to be more effective in reducing long-term production costs and improving product quality consistency (Da Silva et al., 2020).

Cleaner Production in Improving Product Quality

Clean production is not only seen as an environmental control strategy, but also as an instrument for improving the quality and competitiveness of the national food industry. The integration of clean technology with quality management and food safety systems (such as GMP and HACCP) has the potential to produce products that are more physically and chemically stable, microbiologically safe, and have consistent sensory quality (Awuchi, 2023). This approach is increasingly important in supporting the transformation of the Indonesian food industry towards a sustainable, efficient production system that is oriented towards product quality (Fatimah et al., 2020).

The literature search initially identified 73 records from the selected databases, consisting of 18 records from Scopus, 21 from ScienceDirect, 12 from SpringerLink, and 22 from Google Scholar. After removing 9 duplicate records, 64 articles remained for title and abstract screening. At this stage, 37 articles were excluded because they were not relevant to the topic, leaving 27 articles for full-text assessment. Following the eligibility review, 17 articles were further excluded due to limited relevance to Cleaner Production Technology, the absence of clear product quality indicators, or insufficient connection to the Indonesian food industry. Finally, 10 articles were included in the review and used as the main references for the analysis.

Table 1. Summary of Cleaner Production Implementation in the Food Industry in Indonesia

No.	Industry	Quality-Related Problem	Cleaner Production Practice Applied	Product Quality Parameter(s) Affected	Reported Quality Improvement	References
1	Fish cracker industry	Raw materials and finished products were stored in the same humid, dark, and dusty room; manual packaging without hand protection	Consistent implementation of good housekeeping and Good Manufacturing Practices (GMP)	Color uniformity, odor acceptability, texture quality, hygienic handling	Products showed a more uniform color, no pungent odor, and a crispy–chewy texture with improved hygienic handling	Nurhaban et al., 2025
2	Small amplang cracker industry	Unhygienic and inefficient material processing techniques	Development of standard operating procedures (SOPs) for careful processing and improved equipment layout	Hygiene level, shelf-life stability	Products became more hygienic and had a longer shelf life	Atasasih et al., 2024

3	Tofu industry	Workers did not use PPE and consumed food/drinks in the production area	Implementation of Good Manufacturing Practices (GMP)	Hygiene status, contamination risk, shelf-life stability	Products became more hygienic, contamination risk was reduced, and shelf life was extended	Aulia et al., 2023
4	Palm oil industry	Oil and dirt contamination on fresh fruit bunches	Modification of good housekeeping practices	Physical cleanliness, contamination level, CPO quality	CPO and by-products were reported to be safer, with lower contamination and better overall quality	Azzahro et al., 2022
5	Fruit chip industry	Use of substandard tools	Implementation of Good Manufacturing Practices (GMP)	Hygiene status, shelf-life stability	Products became more hygienic and showed improved shelf-life stability	Hadi et al., 2021
6	Tempe industry	Wood burning generated soot and smoke during processing	Modification of good housekeeping practices	Contaminant level, product cleanliness, shelf-life stability	Product contamination was reduced and shelf life was extended	Akbari & Sumarni, 2021
7	Bread industry	Lack of worker SOP implementation, hygiene, and sanitation control	Implementation of worker SOPs, hygiene, and sanitation practices	Hygiene status, shelf-life stability	Bread products became more hygienic and had a longer shelf life	Amrullah et al., 2018
8	Oven peanut industry	Dependence on wood fuel caused processing constraints and smoke-related quality issues	Use of LPG gas-fueled dryer technology	Odor quality, hygiene level	Products became more hygienic and no longer had a burnt-wood odor	Sumadi & Hermanuadi, 2017
9	Nata de coco industry	Poor housekeeping management during production	Disciplined implementation of good housekeeping	Fermentation success, hygiene status, product quality consistency, shelf-life stability	Fermentation performance improved, products became more hygienic and of higher quality, and shelf life increased	Ariyanti et al., 2014
10	Sugar industry	Sugar loss during production	Addition of imbibition water	Sucrose content, process-related quality control parameter (bagasse moisture)	Bagasse moisture increased to 51.9% and sucrose content increased to 2.22%	Yuliandari et al., 2010

The results summarized in **Table 1** show that the reviewed studies did not merely report cleaner production practices in a general sense, but also demonstrated their relationship with specific product quality parameters. Across the ten reviewed articles, the most frequently affected parameters were

hygiene status, contamination level, shelf-life stability, sensory quality, and process consistency. These findings indicate that cleaner production in the Indonesian food industry is closely related to product quality improvement, particularly through better control of sanitation, handling practices, production environment, and processing conditions.

A clearer pattern can be seen when the impacts are grouped by quality parameter. In several food industries, such as small amplang crackers, tofu, fruit chips, and bread, the main reported effects were improvements in hygiene and extended shelf life, indicating that cleaner production contributes to safer and more stable products. In other sectors, the effect was more directly associated with sensory and physical quality attributes. For example, in the fish cracker industry, cleaner production improved color uniformity, odor acceptability, and texture quality, while in the oven peanut industry, the use of LPG drying technology eliminated the undesirable burnt-wood odor. In the palm oil and tempe industries, the main quality improvement was reflected in reduced physical contamination, whereas in the nata de coco industry, cleaner production improved fermentation success and product consistency.

Overall, the table suggests that cleaner production acts not only as an environmental management strategy, but also as a process-based quality improvement approach. Most reviewed studies show that interventions such as good housekeeping, GMP, worker SOPs, sanitation improvement, and cleaner processing technologies can improve quality by reducing contamination sources, stabilizing process conditions, and improving handling discipline. However, the review also reveals that many studies still report quality improvements in qualitative terms, such as “more hygienic” or “longer shelf life,” without consistently presenting detailed quantitative measurements. Therefore, future studies should strengthen the evidence by linking cleaner production practices to measurable quality parameters such as moisture content, water activity, pH, total microbial count, texture, color stability, oxidation indicators, sensory scores, and shelf-life duration.

Conclusion

Based on the reviewed studies, the application of Cleaner Production Technology (CPT) in the Indonesian food industry contributes to product quality improvement mainly through better control of hygiene, contamination, process consistency, and product stability. The reported quality improvements were reflected in several specific parameters, including more uniform color, the absence of undesirable odor, improved texture, reduced contamination risk, better fermentation performance, extended shelf life, and in some cases improved compositional quality such as higher sucrose content. In several industries, particularly fish crackers, peanuts, nata de coco, and sugar processing, cleaner production practices were associated with improvements in sensory, physical, microbiological, and process-related quality attributes. Meanwhile, in tofu, bread, fruit chips, tempe, and amplang crackers, the main effects were improved product hygiene and shelf-life stability.

These findings indicate that CPT should not be viewed solely as an environmental management approach, but also as a practical strategy for improving food product quality. Practices such as good housekeeping, GMP implementation, worker SOPs, sanitation improvement, and cleaner processing technologies help reduce sources of contamination, improve process discipline, and maintain more stable production conditions, which ultimately lead to safer, more consistent, and more acceptable food products. Therefore, the main contribution of CPT in the Indonesian food industry lies in its

ability to enhance specific quality outcomes of food products while simultaneously supporting sustainable production.

References

Abuzar, Sharif, H. R., Sharif, M. K., Arshad, R., Rehman, A., Ashraf, W., ... & Al-Sameen, M. A. (2023). Potential industrial and nutritional applications of shrimp by-products: a review. International Journal of Food Properties 26(2): 3407-3432.

Afum, E., Agyabeng-Mensah, Y., Sun, Z., Frimpong, B., Kusi, L. Y., & Acquah, I. S. K. (2020). Exploring the link between green manufacturing, operational competitiveness, firm reputation and sustainable performance dimensions: a mediated approach. Journal of manufacturing technology management 31(7): 1417-1438.

Akbari, T., & Sumarni, L. (2021). Analisis Penerapan Produksi Bersih Pada Industri Tempe. Agrointek: Jurnal Teknologi Industri Pertanian 15(2): 624-632.

Amrullah, S., Kholis, M. N., & Luketsi, W. P. (2018). Potensi Penerapan Produksi Bersih pada Industri Roti di Ponorogo. Agroindustrial Technology Journal 2(2): 130-140.

Ariyanti, M., Purwanto, P., & Suherman, S. (2014). Analisis penerapan produksi bersih menuju industri nata de coco ramah lingkungan. Jurnal Riset Teknologi Pencegahan Pencemaran Industri 5(2): 45-50.

Atasasih, A., Furwaningsih, S. V., Alamsyah, R., & Aqilah, N. (2024). The Application of Cleaner Production in The Small Industry of Amplang Sembelan Crackers in Kuala Village, Selakau Sub-District, Sambas District. Journal of Fisheries and Marine Applied Science 2(3): 142-149.

Aulia, N. I., Indrasti, N. S., & Ismayana, A. (2023). Penerapan Produksi Bersih pada Industri Kecil Menengah (IKM) Pengolahan Tahu di Indonesia: Literatur Review. Journal of Agroindustrial Technology/Jurnal Teknologi Industri Pertanian 33(1): 10-19.

Aulia, N. I., Indrasti, N. S., & Ismayana, A. (2024). Study and Analysis on The Application of Cleaner Production in The Urea Fertilizer Industry (PT X) in Sumatera. Andalasian International Journal of Applied Science, Engineering and Technology 4(2): 143-155.

Awuchi, C. G. (2023). HACCP, quality, and food safety management in food and agricultural systems. Cogent Food & Agriculture 9(1): 217-280.

Azalia, A., Suroso, E., Hidayati, S., & Joen, D. A. Z. (2020). Model penyulingan minyak atsiri jahe merah berbasis produksi bersih. JTUR 2(2): 238-249.

Azzahro, H. U., Indrasti, N. S., & Ismayana, A. (2022). Penerapan Produksi Bersih pada Industri Kelapa Sawit di PT YZ. Journal of Agroindustrial Technology/Jurnal Teknologi Industri Pertanian 32(1): 1-11.

Da Silva, F. J. G., & Gouveia, R. M. (2020). Cleaner Production. Berlin/Heidelberg, Germany: Springer International Publishing.

Fatimah, Y. A., Govindan, K., Murniningsih, R., & Setiawan, A. (2020). Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. Journal of cleaner production 269: 122263.

Giannetti, B. F., Agostinho, F., Eras, J. C., Yang, Z., & Almeida, C. M. V. B. (2020). Cleaner production for achieving the sustainable development goals. Journal of Cleaner Production, 271: 122127.

Hadi, D. K., Putri, R. A., Farida, S. N., & Santoso, I. (2021). Application of cleaner production in a fruit chips industry. Industria: Jurnal Teknologi dan Manajemen Agroindustri 10(2): 162-171.

Lisboa, H. M., Pasquali, M. B., Dos Anjos, A. I., Sarinho, A. M., De Melo, E. D., Andrade, R., ... & Barros, A. (2024). Innovative and sustainable food preservation techniques: enhancing food quality, safety, and environmental sustainability. Sustainability 16(18): 8223.

Nadya, Y., Yusnawati, Y., & Handayani, N. (2020). Analisis Produksi Bersih Di Ukm Pengolahan Tahu Di Gampong Alue Nyamok Kec. Birem Bayeun Kab. Aceh Timur. Jurnal Teknologi 12(2): 133-140.

Neto, G. C. D. O., Leite, R. R., Lucato, W. C., Vanalle, R. M., Amorim, M., Matias, J. C. O., & Kumar, V. (2022). Overcoming barriers to the implementation of cleaner production in small enterprises in the mechanics industry: exploring economic gains and contributions for sustainable development goals. Sustainability 14(5): 2944.

Nurhaban, N., Auliandini, I., Indah, I., & Wati, R. (2025). Penerapan Produksi Bersih Produk Perikanan Pada Pengolahan Kerupuk Ikan Di Desa Parit Baru Kecamatan Selakau Kabupaten Sambas. Journal of Fisheries and Marine Applied Science 3(1): 31-42.

Pakravan, M. H., & MacCarty, N. A. (2020). Design for clean technology adoption: Integration of usage context, user behavior, and technology performance in design. Journal of Mechanical Design 142(9): 091402.

Pokharel, B., Keerthi, R. S. S., & Abunamous, Z. (2023). Advancements in food processing technologies: Enhancing safety, quality, and sustainability. International Journal of Scientific Research in Engineering and Management 7(6): 10-55041.

Rumanti, A. A., Sunaryo, I., Wiratmadja, I. I., & Irianto, D. (2020). Cleaner production for small and medium enterprises: An open innovation perspective. IEEE Transactions on Engineering Management 70(7): 2355-2368.

Sumadi, F. N. U., & Hermanuadi, D. (2017). Penerapan Teknologi Produksi Bersih (Cleaner Production) Untuk Peningkatan Produktivitas Dan Kualitas Kacang Oven Pada Agroindustri "Ud. Rajawali" Kabupaten Jember. J-Dinamika: Jurnal Pengabdian Masyarakat 2(1): 52-58.

Suryaningrat, I. B., Novita, E., & Kasanah, U. (2020). Cleaner production practices in agroindustry: a case of small scale cheese factory in Indonesia. International Journal on Food, Agriculture and Natural Resources 1(1): 19-23.

Varzakas, T., & Smaoui, S. (2024). Global food security and sustainability issues: the road to 2030 from nutrition and sustainable healthy diets to food systems change. Foods 13(2): 306.

Yuliandari, P., Fauzi, A. M., Suprihatin, S., & Suparno, O. (2017). Kajian Penerapan Produksi Bersih di Stasiun Gilingan pada Proses Produksi Gula. JIEMS (Journal of Industrial Engineering and Management Systems) 3(1): 45-57.