Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

Optimizing Raw Material Mixing Equipment: Evidence from a Dairy Manufacturing Operation in Indonesia

Zhang Xufeng[1]*, Stephanus Remond Waworuntu[1]
[1]President University, Jababeka Education Park, Jl. Ki Hajar Dewantara, RT.2/RW.4, Mekarmukti, Cikarang Utara, Bekasi Regency, West Java 17530, Indonesia
*Corresponding Author: ytnzhangxufeng@yili.com

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE
Xufeng, Z., & Waworuntu, S. R. (2025). Optimizing raw material mixing equipment: Evidence from a dairy manufacturing operation in Indonesia. *Journal of the Community Development in Asia, 9*(1), 1-19.

DOI:
https://doi.org/10.32535/jcda.v9i1.4311

Received: 12 November 2025
Accepted: 15 December 2025
Published: 20 January 2026

ABSTRACT

Inefficient raw material mixing remains a major challenge in large-scale dairy processing, particularly in emerging-market production environments where controlling energy consumption and product uniformity is difficult. This study aims to improve the liquid raw material mixing system at a dairy manufacturing operation in Indonesia by increasing mixing homogeneity while reducing energy intensity during processing. A qualitative descriptive case study approach is employed, drawing on archival production records, organizational documents, operational processes, and patent analysis to examine existing mixing practices and applied process improvements. The study focuses on addressing sedimentation and the uneven distribution of granular solid materials during aseptic conveying and filling stages. Data from production logs indicate that the optimization of combined dynamic and static mixing configurations reduced variability in fruit granulate distribution from approximately 1.5–12% to 2–7.5%, while improving mixing stability and process continuity. Although the findings are specific to the studied case, they provide practical insights into how mixing system optimization can support product quality, operational efficiency, and sustainability objectives in dairy manufacturing under similar production constraints.

Keywords: Dairy Manufacturing; Energy Efficiency; Mixing Homogeneity; Process Optimization; Sustainability

INTRODUCTION

Efficient mixing is a central unit operation in dairy product manufacturing and directly affects final product quality, electricity consumption, and operating costs. Conventional mixing systems often exhibit low process efficiency, high energy demand, and variability in product output. To address these limitations, advanced control and monitoring systems have been proposed as additions to traditional mixing processes, allowing more precise control and in-process adjustment of operating variables. Such systems may improve production uniformity and stability; however, further investigation is required to determine how these technologies can be applied in practice to improve productivity, enable timely adjustments, and maintain stable production conditions (Moejes & Van Boxtel, 2017; Zhang et al., 2020).

Although research on intelligent mixing technologies has expanded in recent years, much of the existing work remains focused on conceptual designs or laboratory-scale validation. As a result, limited attention has been given to the practical engineering and industrial implementation of these technologies, particularly with respect to balancing energy consumption and homogenization efficiency in large-scale dairy operations.

To address this gap, this study examines opportunities to improve liquid raw material mixing equipment through a case study of Yili Company's operations in Indonesia. The study seeks to develop an adaptive process model that links online sensor data with performance indicators, design a real-time control mechanism capable of adjusting operating parameters during production, and assess whether the proposed approach can improve productivity, support adaptive operation, and stabilize the mixing process. From an academic perspective, this study offers a reproducible method for controlling complex mixing processes and contributes practical insights relevant to industrial engineering applications and energy-conscious manufacturing.

Experience drawn from both local and international case studies is used to inform the development of a solution that is technically feasible and socio-economically appropriate for Yili Indonesia. The purpose of this research is to apply knowledge from established practices to address liquid raw material mixing challenges within the Indonesian production context. In doing so, the study considers the alignment between technology development and socio-economic conditions, the feasibility of implementation within PT Indofood CBP Sukses Makmur Tbk, and the broader potential for technological innovation (Clean Energy Ministerial, 2020; International Finance Corporation [IFC], 2007).

The findings of this study are subject to several limitations. As with most case study-based analyses, the results are specific to the examined context and may not be directly transferable to other organizations or settings (Yili Industrial Group Co., Ltd., 2023). In addition, industrial research commonly faces constraints related to data availability and data quality, which require careful verification and management (China Mengniu Dairy Company Limited, 2024). Variability in data access and reliability at Yili Indonesia and similar facilities may therefore influence the scope of the analysis.

Problem Identification and Significance

High-efficiency mixers contribute to improved product quality through more uniform mixing while also reducing energy consumption, thereby supporting environmental sustainability objectives. Previous studies have identified energy-saving potential through the application of newer technologies in milk processing, including milk powder production (Moejes & Van Boxtel, 2017). However, in the Indonesian context, limitations in technical skills and equipment maintenance capabilities may affect the long-term adoption and continuity of such solutions (Oliveros, 2019). In addition, regulatory constraints related to equipment importation and energy use can further limit available technological options (Ministry of Investment and Downstream Industry [BKPM], 2023). Data availability and data quality remain additional challenges in industrial research and require appropriate validation to ensure reliable analysis (China Mengniu Dairy Company Limited, 2024).

Yili's factory production process consists of multiple stages, including mixing, preheating, homogenization, sterilization, cooling, aging, freezing, molding, packaging, warehousing, inspection, and product dispatch. Most production equipment is imported and features a high level of automation, which supports stable product quality. Despite this, the mixing stage remains a key source of operational inefficiency.

The first major issue is the inefficiency of the existing mixing process. Instability during mixing increases both processing time and energy consumption. Data reported by Yili Industrial Group Co., Ltd. (2023) indicate that the mixing facility accounts for a large share of total production energy use while operating at a relatively low efficiency level. This combination of high energy demand and limited output efficiency represents a significant operational and cost-related concern.

The second issue concerns mixing homogeneity. Current mixing practices do not consistently achieve uniform liquid raw material mixtures, resulting in variation in texture, taste, uniformity, and product stability. These factors directly influence overall product quality and customer satisfaction.

The third challenge relates to adaptation to local operating conditions. Many commercially available mixer technologies are not well-suited to Indonesia's production environment, which includes infrastructure constraints and variable operating conditions. Factors such as unstable voltage supply and high humidity can adversely affect mixer performance and operational stability.

Finally, the existing mixing system lacks advanced control and monitoring capabilities. Limited process control, insufficient monitoring performance, and low adaptability to changing production conditions restrict system effectiveness. Within this technical and operational context, this study defines a set of objectives that form a coherent basis for addressing inefficiencies in liquid raw material mixing.

LITERATURE REVIEW

Concept of Raw Material Mixing System

High-tech solutions in the food and beverage industry play an important role in improving product quality while reducing production costs. The integration of robotics supports these objectives by increasing operational efficiency, minimizing waste, optimizing resource utilization, and enhancing overall production performance, thereby directly contributing to sustainability goals (Lukman et al., 2024). In line with this approach, Yili Indonesia has adopted advanced technologies to reduce waste and improve product quality, which in turn lowers production costs.

The project development adopts a systematic innovation framework grounded in Lean Manufacturing principles. This framework includes: (1) waste elimination in the mixing process, identified through detailed process analysis; (2) Quality Function Deployment (QFD) to translate customer requirements, particularly product consistency, into technical specifications; (3) the TRIZ methodology to resolve contradictions between mixing uniformity and energy consumption; and (4) the application of current state-of-the-art liquid raw material mixing technologies.

Over recent decades, liquid mixer technology has evolved significantly in response to increasing demands for improved mixing performance. Contemporary mixing system designs increasingly combine high-shear mixers with multi-stage mixers to achieve uniformity while minimizing energy consumption. Goff (2019) explains that high-shear mixing enables a more homogeneous product, which enhances consumer satisfaction by improving texture and stability. Additionally, advances in mixer construction, including the use of dynamic stirring structures, have been proposed to address material stratification and further improve mixing effectiveness (Mou & Zhang, 2024).

Figure 1. Conceptual Diagram of the Optimized Raw Material Mixing System

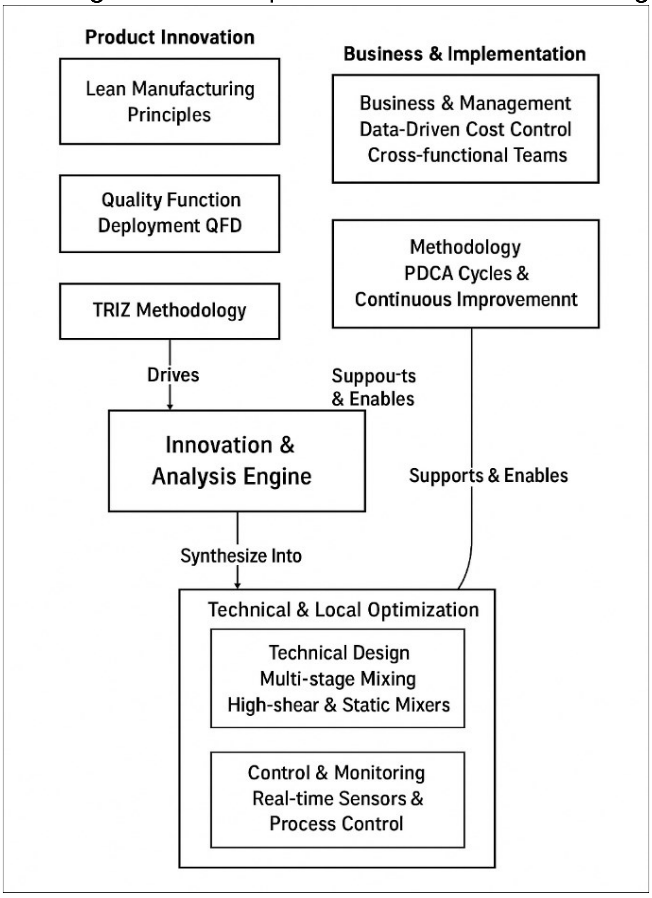


Figure 1 illustrates how a systematic innovation framework composed of technical, managerial, and local innovation interventions might be implemented to improve Yili Indonesia's liquid raw material mixing system. At the foundation, the project is driven by Lean Manufacturing, QFD, and TRIZ methodology.

Lean minimizes waste in the mixing process through process analysis (Yili Industrial Group Co., Ltd., 2023). QFD translates customer requirements (e.g., product uniformity) into measurable engineering targets (Goff, 2019). TRIZ resolves the contradiction between achieving uniform mixing and reducing energy consumption (Moejes & van Boxtel, 2017). These axioms govern the operation of the innovation and analysis engine, the essential core of the system, that fuses the synthesis of engineering design and analysis (driven by data) with problem-solving to yield design optimizations (Lukman et al., 2024).

The business and implementation layer provides the organizational and managerial support necessary to ensure effective execution. This layer emphasizes data-driven cost control, cross-functional collaboration, and the use of Plan–Do–Check–Act (PDCA) cycles to enable continuous improvement. Performance improvement indicators, such as cost optimization in ready-to-eat products, are explicitly aligned with corporate performance objectives by leveraging Yili's cost optimization experience in both China and Indonesia (Yili Industrial Group Co., Ltd., 2023).

The output layer (technical and local optimization) integrates these managerial outcomes into practical solutions. First, the technical design incorporates high-shear and multi-stage mixer technologies, which have been shown to improve product homogeneity while reducing energy consumption (Luo et al., 2005). Second, control and monitoring systems employ real-time sensors to support process control and maintain consistent product quality (IFC, 2007). Third, localization efforts adapt these technologies to Indonesia's infrastructural constraints, addressing challenges such as variable raw material quality and imbalanced raw material inputs (BKPM, 2023; Oliveros, 2019).

This framework is grounded in established regional and global best practices within the dairy industry, particularly those related to mixing homogenization, process energy efficiency, and measurement systems, as well as national policies and key technologies in mixing systems (Goff, 2019; Mou & Zhang, 2024). These practices provide a mature technical and managerial foundation for improving product quality and operational performance.

In recent years, a wide range of high-shear, multi-stage, and turbulence-enhancing mixing devices has been developed to achieve efficient and uniform liquid mixing (Mou & Zhang, 2024). As a result, contemporary mixing systems increasingly rely on the integration of these technologies rather than on single-device solutions. Empirical evidence supports this approach. For example, Luo et al.'s (2005) study demonstrates that multi-stage mixing can significantly shorten mixing time while improving liquid uniformity. In addition, turbulence amplification techniques have been shown to enhance mixing performance by increasing advective turbulence within the mixing chamber.

Within the dairy sector, standardized liquid mixing practices have long been recognized as a fundamental requirement for product quality control and as an effective means of improving operational efficiency (Goff, 2019). Several dairy manufacturers have translated these standards into practice to support business performance. Notably, the 2023 sustainability report of Inner Mongolia (Yili Industrial Group Co., Ltd., 2023) highlights the optimization of mixing parameters to achieve higher efficiency and improved overall product quality. Such practices imply the systematic use of online control and monitoring systems to ensure that appropriate mixing conditions are consistently maintained during production.

Homogeneous mixing plays a critical role in ensuring the uniformity and overall quality of food products. In dairy processing, mixing homogeneity directly affects product durability, texture, and sensory attributes. Prior research shows that achieving a homogeneous mixing state significantly improves product uniformity, underscoring uniform mixing as a key determinant of food product quality (Loncin, 2012). For industrial processes, homogeneity can be understood as the degree of similarity between a given processing stage and its prerequisites, such as uniform milk composition, which is essential for controlling texture quality and flavor profiles that ultimately shape consumer acceptance.

Furthermore, mixing homogeneity influences not only product uniformity but also structural consistency and final quality. Evidence indicates that dairy product consistency improves substantially when a high degree of mixing homogeneity is achieved, highlighting the strong relationship between uniform mixing and product performance (Loncin, 2012). In this context, homogeneity in dairy processing represents a necessary condition for maintaining final product texture and flavor, which are among the most important drivers of consumer acceptability.

To enhance mixing effectiveness, a range of technical measures has been adopted in industrial practice. These measures include optimized mixer structural design, precise control of mixing parameters, advanced control systems, and real-time monitoring technologies (Goff, 2019). For instance, Wang (2017) introduced a modular design concept for mixer and process control systems, enabling robust performance and optimal parameter control in a highly energy-efficient manner. Collectively, these technical advancements reinforce the importance of integrating equipment design, process control, and monitoring systems to achieve consistent and efficient mixing outcomes.

Challenges and Opportunities of Production Efficiency

Local production, for example, in Indonesia, is limited by resource constraints and technical adaptability. Oliveros (2019) raised important topics regarding the dairy industry in Southeast Asian countries, including limited infrastructure and unbalanced raw material quality. An efficient and flexible mixing technology can help to overcome such challenges.

Although not easy, some localization approaches have already demonstrated success, such as the localization in the Clean Energy Ministerial (2020), which has achieved tremendous energy savings through the installation and use of an energy management system. Based on this case study, we understand that it is practical to tailor sophisticated technologies to the local production setting, and we hope that the same approach can be applied to the dairy sector as well.

Finally, local policy and regulation also play an important role in the adoption of new technology. BPKM (2023) provides information on Indonesia's legal framework and investment opportunities. Local policies should be understood to inform the design of a mixing technology that meets local needs and contributes to sustainable development.

Business and Management Foundation

According to Yili Industrial Group Co., Ltd. (2023), after the granular products Anmushi Tetra Pak and Guoli You entered production in early 2017, the Equipment Management Department closely monitored the uniformity of fruit grains in finished products. The monitoring results indicated substantial fluctuations in fruit grain content per package, with consumption per ton exceeding the established standards of 115 kg/ton for Tetra Pak and 80 kg/ton for Guoli You. In response, the Equipment Management Department, in collaboration with the Production Management Department, launched a comprehensive action plan to reduce excessive fruit granule usage and mitigate associated cost losses. Improvement measures were implemented across multiple dimensions, including raw milk management and the optimization of raw and auxiliary materials, leading to effective cost control. As a result of these initiatives, cumulative savings reached 80.9274 million yuan by September 2019, including 52.1039 million yuan for Tetra Pak products and 28.8235 million yuan for Guoli You products (Yili Industrial Group Co., Ltd., 2023).

According to Yili Industrial Group Co., Ltd. (2023), cost reduction efforts for granular products were further strengthened in 2018 through the refinement of the Cost Reduction

Work Plan for Granular Products by the Equipment Management Department and the Production Management Department. The revised plan expanded its scope to include normal-temperature yogurt granular products and introduced raw material yield rate as a key assessment indicator, thereby increasing the potential for cost optimization. Progress toward these objectives was systematically monitored through monthly cost reduction briefings. During implementation, a series of technical and operational measures was adopted, including the promotion of jam ton boxes, standardization of inspection methods for granular content, adjustment of series and parallel configurations in pretreatment feeding systems and filling lines, standardization of process parameters, optimization and installation of static mixers to regulate granular addition ratios, improvement of online sampling practices, and the installation of new rotor pumps with adjusted rotation directions to better control granular proportions. As a result, total savings in 2018 reached 29.8082 million yuan, comprising 18.172 million yuan from Tetra Pak products and 11.6362 million yuan from Guoli You products (Yili Industrial Group Co., Ltd., 2023).

Subsequent efforts focused on consolidating and institutionalizing successful cost reduction practices. These included full coverage of jam ton boxes to reduce jam residue losses, further optimization of base material pasteurization temperature parameters, reduction of tank bottom residue, and reinforcement of standardized granular addition ratios, thereby embedding cost reduction practices into routine production processes. Between January and September 2019, these measures generated additional savings of 51.1192 million yuan, of which Guoli You products accounted for 17.1873 million yuan, while Tetra Crown products achieved cumulative savings of 33.9319 million yuan (Yili Industrial Group Co., Ltd., 2023).

Building on these documented practices, the present study focuses on Yili Indonesia's specific production context, as outlined in the 2023 sustainability report, to ensure relevance to the company's operational challenges. The technological scope is narrowed to liquid mixing technology, excluding solid and gas-liquid mixing, in response to issues identified in prior studies and the need to address problems arising specifically from liquid raw material mixing (Luo et al., 2005). In addition, consumer loyalty is considered a broader outcome dimension, given empirical evidence from the technology sector indicating that perceived value and brand trust exert significant positive effects on consumer loyalty, while brand experience and social influence play a more limited role (Hui et al., 2024). Finally, the Indonesian local context is explicitly incorporated by accounting for resource conditions and infrastructural constraints identified in BPKM (2023) and Oliveros (2019), thereby increasing the practical applicability and resilience of the proposed solutions (BKPM, 2023; Oliveros, 2019).

RESEARCH METHOD

This study adopts an applied single-case study approach with a descriptive qualitative orientation. The purpose is not to test causal hypotheses or manipulate process variables, but to analyze and interpret existing operational practices within a real industrial setting. Data were derived primarily from internal production records, technical documentation, and sustainability reports, which were examined to identify process inefficiencies, energy-use patterns, and opportunities for technological improvement. This approach is appropriate for investigating complex production systems where experimental control is impractical and where contextual factors play a central role in shaping operational outcomes.

The case study is conducted at Yili Indonesia's manufacturing plant, which represents a multinational enterprise operating within an emerging-market context. This setting is particularly suitable for examining process-level inefficiencies and for identifying opportunities for process redesign and technological improvement under practical industrial constraints.

The findings of this research are intended to offer practical and actionable insights that support decision-making at both operational and managerial levels. Consistent with its applied orientation, the study emphasizes not only the analysis and description of current conditions but also the development of feasible recommendations aimed at improving industrial process performance.

Data Collection

The research uses documentary methods, relying exclusively on secondary data from existing organizational documents. The document analyzed included: First, archival and documentary data were reviewed, including corporate operational reports, sustainability disclosures, and internal process documentation related to mixing operations. Publicly available materials, such as the Yili 2023 Sustainability Report (Yili Industrial Group Co., Ltd., 2023), were also examined to identify corporate process optimization practices and sustainability objectives.

Second, patent searches were conducted to analyze the technical logic and operating principles of mixing technologies developed by Yili Group, including CN113546535B (Liquid Raw Material Mixing Equipment) and CN113546566A (Raw Material Mixing System and Method). This analysis focused on understanding existing industrial solutions rather than treating patent claims as empirical data.

Third, operational process data were obtained from the Yili Indonesia production line, covering mixing time, temperature, power consumption, and material uniformity. These data were used as qualitative and descriptive inputs to support process assessment rather than as controlled experimental measurements. Data were collected from multiple sources to support triangulation and ensure methodological rigor.

Data Analysis

Data analysis in this study focused on systematically understanding the existing raw material mixing process. The process involved reducing data by selecting relevant information from documents on process flow, equipment performance, and energy usage, then organizing it into tables, diagrams, and narrative descriptions to clearly present operational conditions. Finally, the data were interpreted to identify patterns, inefficiencies, deviations from standards, and potential areas for improvement. The overall analysis aims to provide a comprehensive description of the mixing process while highlighting gaps between actual practices and established technical or operational standards.

Validation and Reliability

Several measures were undertaken to enhance the credibility and reliability of the findings. Internal validation was conducted through discussions with experts from Yili's Equipment and Production Management Department to assess the realism and practical relevance of the results. Patent documentation was also reviewed to verify consistency between the proposed ideas and established technological knowledge.

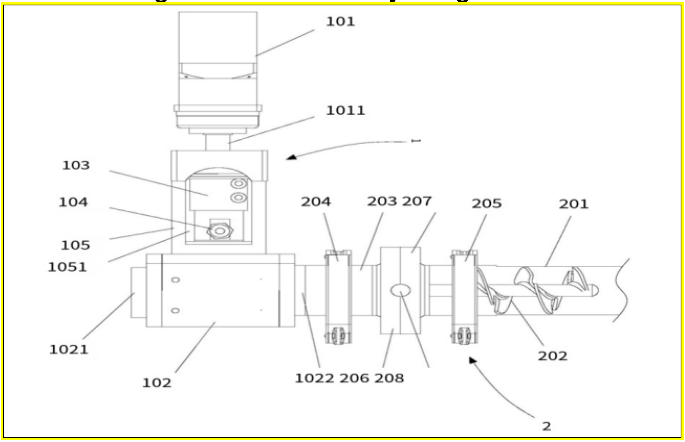
Furthermore, comparisons with analogous cases from other industries were used to evaluate the plausibility and potential generalizability of the proposed solutions. This triangulation serves as an additional validation mechanism, supporting the trustworthiness of the findings derived from this exploratory qualitative case study.

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

RESULTS

The features and advantages of the raw material mixing device, the aseptic raw material mixing system, and the aseptic raw material mixing method of the present invention are as follows: Before canning, the granular raw materials and liquid raw materials need to pass through a dynamic mixing device and a static mixing device in sequence. Stirring and mixing effectively improve the uniformity of the granular raw materials in every single package after canning, enhance product quality, and reduce production costs. Additionally, the granular raw materials and liquid raw materials remain in a sterile state throughout the mixing and canning process, effectively extending the product's shelf life.

Figure 2. Raw Material Mixing Device Assembly Diagram



Further, as shown in Figure 2, a third clamp 204 is fixedly sleeved on the outer side of the conveying pipe 203. A fourth clamp 205 is fixedly sleeved on the outer side of the second shell 201 near the second inlet 2011, thereby enhancing the stability of the connection between the conveying pipe 203 and the second shell 201.

Figure 3. Detailed View of the Dynamic Mixing Chamber

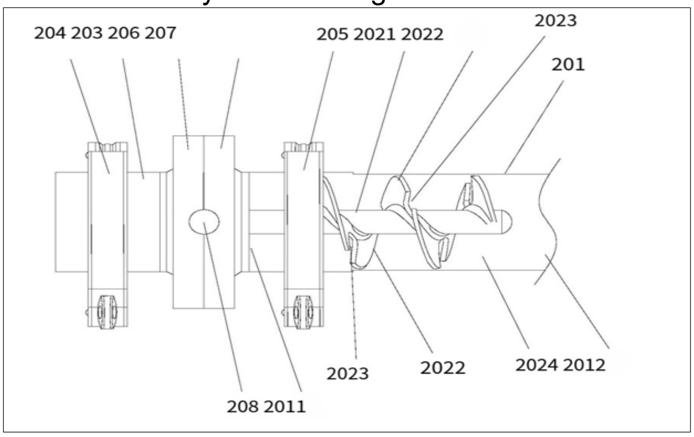


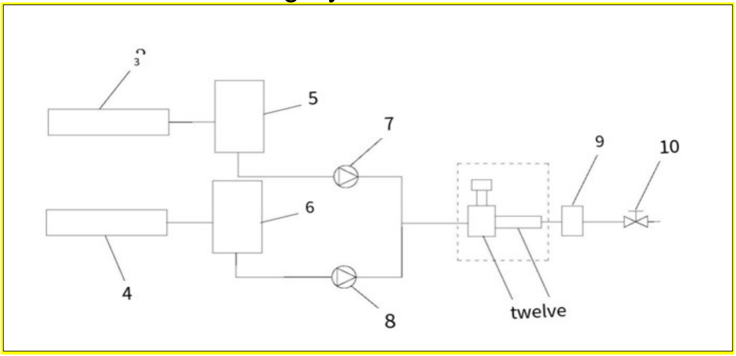
Figure 3 shows that the raw material mixing device of the present invention offers several notable features and advantages. It is equipped with a dynamic mixing device and a static mixing device that are connected in sequence. This continuous stirring and mixing ensure that the granular and liquid raw materials remain uniformly distributed during the filling stage, thereby improving the consistency of granular content in each package, enhancing overall product quality, and reducing production costs.

The dynamic and static mixing equipment in this raw material mixing device are both made of the highest quality food-grade materials, and the material passage is sealed,

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

eliminating the need for an open mixing system. The dynamic and static mixing equipment minimizes the risk of product contamination. It can be cleaned and disinfected online, eliminating potential contamination threats. Under the premise of ensuring product quality and organizational state, it protects the product's texture from damage, reduces loss, and can gently handle raw materials with easily damaged shapes, achieving precise distribution of raw materials containing particles.

Figure 4. Aseptic Raw Material Mixing System Schematic



As shown in Figure 4, a first transfer pump is installed on the raw material transfer pipeline between the first sterile tank and the raw material mixing device, while a second transfer pump is arranged on the pipeline between the second sterile tank and the raw material mixing device. Through these transfer pumps, sterilized granular raw materials are delivered to the first sterile tank, and sterilized liquid raw materials are delivered to the second sterile tank, respectively. In addition, a stop valve is installed on the raw material conveying pipeline between the filling machine and the filling production line to control the start and stop of the filling process.

The aseptic raw material mixing system of the present invention demonstrates significant characteristics and advantages. During the conveying, mixing, and filling processes, the coordinated operation of the dynamic mixing device and the static mixing device ensures that granular and liquid raw materials remain uniformly mixed. This design prevents the settling or uneven distribution of granular materials within the liquid phase, maintaining the content variation of granular raw materials in each individual package within a range of 2% to 4%. As a result, the uniformity of granular content in each package is improved, product quality is enhanced, and production costs are reduced. Furthermore, by applying high-temperature sterilization to granular and liquid raw materials through the respective sterilization equipment, the entire process of conveying, mixing, and filling is conducted under sterile conditions, thereby effectively ensuring product safety and extending shelf life.

Throughout the transportation, mixing, and filling of granular and liquid raw materials, the dynamic and static mixing devices operate in coordination to maintain uniform material distribution. This continuous and controlled mixing prevents sedimentation of granular raw materials, improves consistency after filling, enhances overall product quality, and contributes to cost reduction. At the same time, maintaining a sterile environment throughout these processes ensures product quality and prolongs shelf life.

Liquid Raw Material Mixing Equipment, Raw Material Mixing System, and Raw Material Mixing Method
Inside the mixing tube, along its axial direction, a core shaft is provided. The outer wall of the core shaft is equipped with first and second guide vanes, both of which are helical in structure. The extension direction of the first guide vane on the outer wall of the core shaft is opposite to that of the second guide vane. Multiple first liquid passage holes and

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

multiple second liquid passage holes are respectively provided on the first and second guide vanes.

Figure 5. Liquid Raw Material Mixing Equipment Diagram

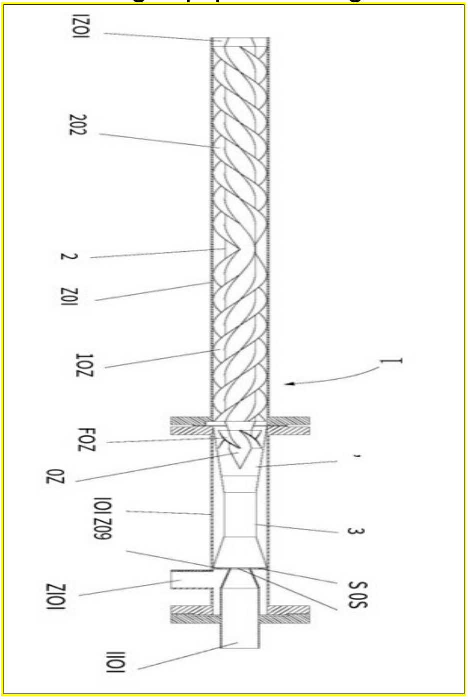
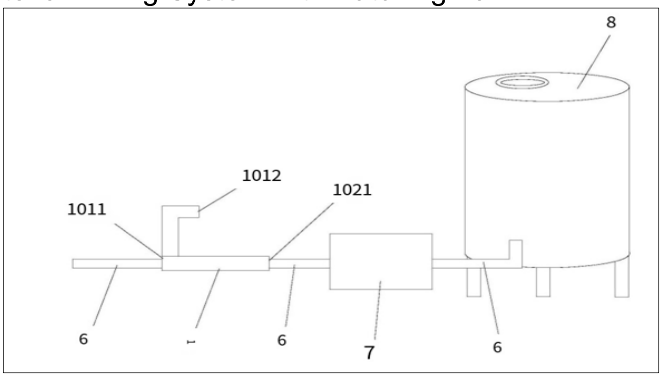


Figure 5 shows that the liquid raw material mixing device uses the first guide vane 201 and the second guide vane 202 to guide and mix the two liquid raw materials. Moreover, when the two liquid raw materials flow to the second guide vane 202, their original spiral motion direction changes, causing them to roll and mix inside the mixing tube 1, thereby enhancing the uniformity of the mixture.

Figure 6. Raw Material Mixing System with Batching Tank



As shown in Figure 6, the proposed mixing system integrates dynamic and static mixing mechanisms to address sedimentation and non-uniformity during conveying and filling processes, which includes a batching tank and the aforementioned liquid raw material mixing device. The first raw material inlet 1011 of the liquid raw material mixing device is connected to the storage tank for the first liquid raw material through a feeding pipe 6, and the second raw material inlet 1012 is connected to the storage tank for the second liquid raw material through a feeding pipe 6. The mixed material outlet 1021 of the liquid raw material mixing device is connected to the batching tank 8 through a feeding pipe 6.

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

The Characteristics and Advantages of the Raw Material Mixing System of the Present Invention

Through the liquid raw material mixing equipment, it is possible to ensure the uniform mixing of various raw materials, effectively improving the uniformity of multiple liquid raw materials in every single package after filling, enhancing product quality, and reducing production costs. The above description is merely a specific embodiment of the present invention and is not intended to limit the scope of the invention. Any equivalent variations and modifications made by those skilled in the art without departing from the concept and principles of the present invention should fall within the scope of protection of the present invention.

Innovation in the Dynamic Mixing Process Technology for Sterile Granular Products

Project Highlights and Value

The Equipment Management Department, Production Management Department, and the management teams of each factory carried forward the Yili spirit of pursuing excellence and taking responsibility, and improved step by step, in order to solve the cost loss problem of Amuxilile Crown and Fruit grain premium. How did they manage to have the Tetra Crown production line recognized by Tetra Pak as the "Best operating Tetra Crown Production line in the world"? First, a detailed review of the equipment process was carried out, and a detailed plan was formulated, revealing many unreasonable aspects of the equipment process and installation:

Experimental Results

Figure 7. Fluctuation Curve of Fruit Content in Production

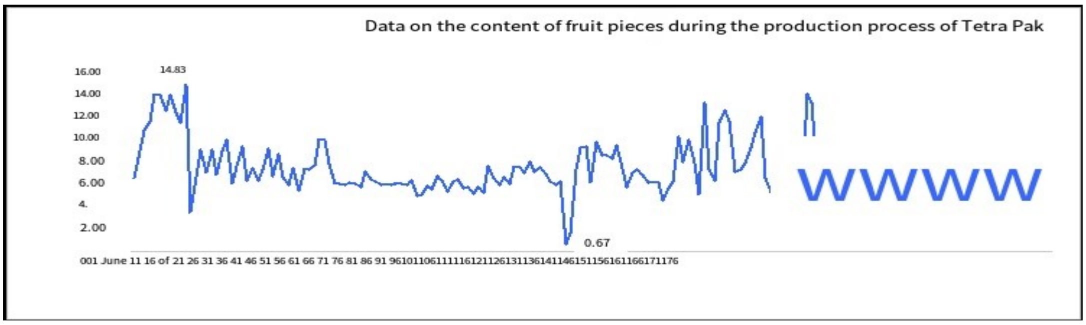


Figure 7 shows that uneven fruit content was found during the production process. Inventions, discoveries, and innovations (including whether the technology is a breakthrough.

Optimization

Production Line Process Configuration Parameters

Table 1. Normal Distribution of Fruit Granule Content per Package

Yogurt Aseptic Cans	Pouring temperature	27.8 ℃
	Perfusion pressure	1.2 bar
	Stirring speed	0r/min
Fruit Granule Sterile Canister	Infusion temperature	26.1 ℃
	Perfusion pressure	1.2 bar
	Stirring speed	11r/min
Mix Aseptic Cans	Infusion temperature	27.9 ℃
	Perfusion pressure	0.9 bar
	Stirring speed	8r/min
	Add proportion	7.7%
	Yogurt pump frequency	21.2 / HZ

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

	Fruit granule pump frequency	7.1 / HZ
	Low-level feed	20%
	High-level stop	60%
Fill Machine Product Barrels	Feed valve opening	25%
	Stirring speed	20r/min

Regarding the cost reduction of fruit granule products, the Equipment Management Department, in conjunction with the Production Management Department, established a special improvement team. Table 1 shows the process configuration parameters of each factory production line and the normal distribution curve data of fruit granule content per package of products. They held more than ten special analysis meetings with various departments of the factory, and finally formed improvement countermeasures.

Improvement Measures

Figure 8. Improvement in Fruit Granule Distribution After Process Parameter

Figure 8 shows the improvement in Fruit Granule Distribution after the process parameter. To further stabilize milk and fruit granule mixing, the operation sequence of the rotor pumps was modified by setting the fruit granule rotor pump as active (starting first) and the yogurt rotor pump as driven (starting later). It was also observed that series feeding caused significant differences in particle content between machines due to particle flow characteristics in the pipeline, where low flow rates led to particle agglomeration. Consequently, the fruit content of products discharged from different machines varied considerably. To address this issue, the feeding lines between machines were converted into sterile circular feeding lines, and pressurized rotor pumps operating in reverse were installed in the middle of the pipelines to redistribute particles. This modification ensured a more uniform particle distribution along the feeding line and consistent particle entry into each machine.

In addition, a self-designed and developed mixer was installed at the inlet of the aseptic mixing tank. Following this equipment modification, particle content variability was significantly reduced, with the range decreasing from 1.5%–12% to 2%–7.5%. Finally, the standard for fruit particle addition was revised. The internal control requirement for particle content per package was changed from a fixed threshold of “≥ 2.0 g/100 g” to a formulation-based standard, whereby the addition amount must comply with the ingredient record specified in the production formula.

An Innovative Description of the Project Results

Self-developed and designed dynamic and static mixers (with national patent application) for online addition and mixing.

Figure 9. Self-Developed Dynamic and Static Mixer Design

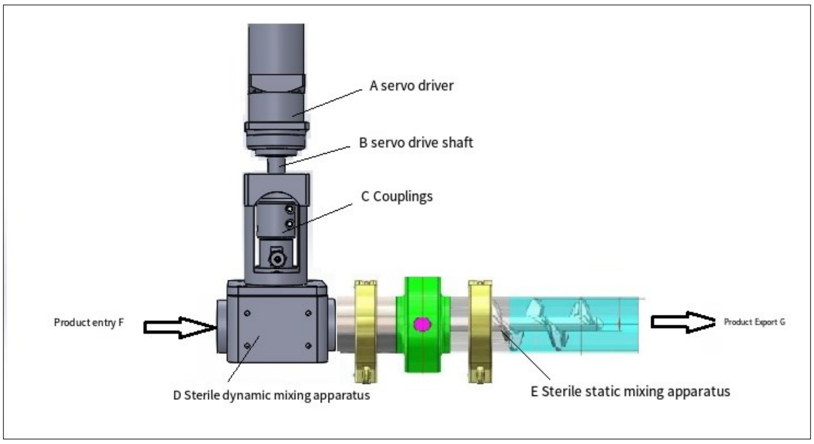


Figure 9 illustrates the self-developed dynamic and static mixer design. The development and application of this online additive mixing system aim to ensure both product quality and operational stability. The mixing system is designed to protect product texture from damage, reduce material loss, gently handle ingredients with fragile structures, and achieve precise and uniform distribution of granular materials. To meet these requirements, the dynamic and static mixers are constructed from high-quality food-grade materials, and the material flow passages are fully sealed, eliminating the need for an open mixing system and thereby minimizing the risk of product contamination. In addition, the system is designed in accordance with 3A sanitary standards, enabling Clean-in-Place (CIP) and Sterilize-in-Place (SIP) processes for in-line cleaning and disinfection, which effectively reduce potential contamination risks. The Equipment Management Department, in collaboration with the Production Management Department, conducted detailed investigations and data collection on the mixing processes of granular products to support the design and implementation of this system. The feasibility and applicability of the technological solution are further evaluated based on its performance under actual production conditions.

In contrast, localized mixing techniques emphasize adaptability, cost-efficiency, and sustainability, focusing on tailoring solutions to the specific operational realities of the Indonesian manufacturing context. This approach acknowledges the limitations in energy availability, skilled labor, and technological infrastructure that may impede the effectiveness or feasibility of implementing more capital-intensive strategies.

Moreover, by grounding the mixing process in locally available resources and capabilities, this alternative enhances operational resilience and promotes self-reliance, which are critical for long-term sustainability. It also opens pathways for innovation through the integration of indigenous knowledge and practices, potentially fostering inclusive industrial development. Compared to the more generalized or technologically dependent alternatives, such as synthesizing global case studies (alternative 5) or optimizing control factors (alternative 2), this option ensures that the developed techniques are not only scientifically sound but also practically implementable within local constraints.

DISCUSSION

The plant-based food and beverage sector has expanded rapidly in recent years, driven by rising consumer demand for sustainable and health-oriented products, as well as advances in food processing technologies. Product quality and sensory performance remain central determinants of consumer acceptance. Karimidastjerd et al. (2024) demonstrated that formulation choices significantly influence texture, rheology, and sensory attributes in vegan rice puddings prepared with different plant-based milks. In a broader review, Mehany et al. (2024) emphasized that technological innovation and formulation strategies play a key role in improving nutritional value, functional properties, and overall product quality in plant-based milk analogs. Visual characteristics are also critical; Wannasin and McClements (2023) showed that pigment composition and droplet properties directly affect the optical appearance of plant-based emulsions, providing guidance for improving product presentation. Together, these studies indicate that ingredient selection, processing technology, and formulation design jointly shape product quality and consumer perception.

Within this context, the development of localized mixing techniques that are compatible with Indonesia's infrastructure and resource conditions represents a context-appropriate strategy for improving Yili Indonesia's liquid raw material mixing process. Although alternatives such as advanced equipment redesign and automated control systems offer technical advantages, they often require substantial capital investment, technological dependence, and operational complexity. These requirements may not align with the industrial ecosystem and infrastructure capacity in Indonesia. Accordingly, this study emphasizes efficiency optimization, quality improvement, and sustainability as interrelated priorities in dairy manufacturing, where optimization methods and sustainability considerations form an integrated foundation for modern production systems.

Changes in food production processes have increasingly been driven by advances in processing techniques and technology adoption. Moejes and Van Boxtel (2017) showed that the application of new technologies in dairy production can reduce production costs, particularly through improvements in mixing procedures that lower energy consumption. Energy efficiency has therefore become a central issue in sustainable production. During food manufacturing, particularly under aseptic conditions, the effective mixing of multiple raw materials is essential for maintaining both nutritional value and sensory quality. Ensuring uniform mixing between liquid and granular solid raw materials under sterile conditions remains a major challenge for the food industry. In agroindustrial production systems, the combined importance of process efficiency and sustainability has been widely recognized. Adegbola et al. (2022) demonstrated that optimization techniques in milk pasteurization can reduce energy consumption while preserving product quality. Similarly, Batuta and Abd. Rahman (2023) showed that structured process improvement contributes to higher efficiency and more consistent product quality. These findings confirm that process optimization is directly linked to both sustainability outcomes and production performance.

The results of this study indicate that Yili Indonesia applies a production method in which granular solid raw materials and liquid raw materials are sterilized separately and then mixed in a sterile environment at predetermined proportions. However, during pipeline transportation, fluid dynamics cause sedimentation of the granular solids. As a result, when the mixed materials reach the filling equipment, solid components have already settled. Filling under these conditions leads to uneven distribution of granular solids in the final products, producing significant variation in the solid–liquid ratio across packages. This imbalance not only results in raw material waste but also negatively affects product taste and overall quality consistency.

In parallel with product development, optimization techniques are increasingly applied to improve both biological and production performance. Samimi et al. (2023) demonstrated the value of systematic experimental design through the use of response surface methodology to optimize plant growth factors. Tejaningrum and Putra (2022) further identified responsiveness, reliability, and efficiency as key determinants of performance outcomes. These studies indicate that the development of plant-based and dairy-related

Journal of the Community Development in Asia (JCDA)
Vol. 9 No. 1, pp.1-19, January, 2026
E-ISSN: 2654-7279 P-ISSN: 2685-8819
https://ejournal.aibpmjournals.com/index.php/JCDA/index

products requires an integrated approach that combines scientific optimization, technological development, and consumer-oriented considerations. Such integration ensures that products meet sensory and nutritional expectations while also supporting operational efficiency and sustainability objectives.

Current mixing technologies have not adequately resolved sedimentation during material conveying, resulting in persistent non-uniformity between granular solids and liquid raw materials. To address this limitation, the proposed integrated technical solution introduces a sterile raw material mixing system that maintains sterility throughout conveying, mixing, and filling processes, thereby supporting product quality and shelf-life extension. This system combines dynamic and static mixing mechanisms: a dynamic mixing unit facilitates effective blending of granular and liquid components, while a static mixing unit prevents sedimentation within the liquid phase. Through this configuration, uniform distribution and stability of raw materials are maintained throughout the production process.

From an environmental perspective, sustainability has become a central concern in contemporary food manufacturing. Detzel et al. (2022) showed through life cycle assessment that plant-based products generally generate lower ecological impacts. Apriono et al. (2023) found that firms with stronger financial performance and environmental awareness demonstrate more comprehensive Environmental, Social, and Governance disclosures in the agro-industrial sector. Sharma et al. (2024) identified increasing consumer preference for environmentally responsible and health-oriented beverages, reinforcing the importance of sustainable production strategies. In operational contexts, Lukman et al. (2024) reported that robotics and automation in beverage production improve productivity and sustainability while also supporting workforce well-being. Regional industry perspectives (Oliveros, 2019) and food engineering principles (Loncin, 2012) further provide strategic and regulatory frameworks for aligning production systems with safety and quality standards. Collectively, these studies indicate that quality improvement, process optimization, and environmental responsibility can function as complementary objectives, supporting sustainable growth and long-term competitiveness in modern food manufacturing.

CONCLUSION

This study highlights the interrelated roles of product quality, process efficiency, and sustainability in contemporary food manufacturing in Indonesia. The findings show that sensory attributes, visual appearance, and nutritional performance are closely influenced by formulation choices and processing technologies. At the same time, process optimization plays an important role in reducing energy consumption and improving operational consistency. Despite these improvements, challenges persist in aseptic processing, particularly in achieving uniform mixing between solid granular and liquid raw materials during conveying and filling stages.

Energy consumption during mixing emerges as a critical issue, especially at the industrial scale. The results indicate that optimizing mixing operations has meaningful implications for overall energy use, which is increasingly relevant in the context of sustainable production systems. Efficient mixing, therefore, contributes not only to improved product quality but also to reduced environmental impact and lower operating costs.

From a managerial perspective, both equipment and production management are under continuous pressure to minimize production losses through waste reduction and cost control. The findings demonstrate that targeted improvements in mixing technology can be translated into practical operational measures within real production environments. In this context, mixing systems have progressed from mechanically driven homogenization toward more advanced configurations that incorporate active and passive mixing concepts, with greater emphasis on maintaining product consistency.

The study also identifies key limitations of existing mixing technologies, particularly non-uniformity caused by sedimentation, which can result in product inconsistency, raw material losses, and degradation of sensory quality. To address these issues, the proposed integrated mixing approach, combining dynamic and static mixing mechanisms, provides a practical means of maintaining sterility, preventing particle settling, and ensuring homogeneous distribution throughout the production process. By stabilizing the ratio of solid and liquid components, this approach supports improved product quality, extended shelf life, and more consistent consumer acceptance.

Importantly, the emphasis on localized and adaptive mixing solutions reflects Indonesia's infrastructural and resource conditions, thereby enhancing the practicality and economic feasibility of the proposed approach. Rather than suggesting universal applicability, the findings offer context-specific insights that may inform similar manufacturing settings facing comparable operational constraints. Overall, this study demonstrates that process optimization and sustainability objectives can be aligned through appropriate technological choices, contributing to more efficient and sustainable manufacturing practices in the dairy and plant-based food sectors.

LIMITATION

Several limitations should be acknowledged. First, reliance on secondary data confines the analysis to information recorded in existing documentation and may not fully capture informal practices or undocumented operational issues. Second, as a single case study, the findings are inherently context-specific and may not be directly generalizable to all dairy manufacturing settings. Nevertheless, the insights remain analytically transferable to similar industrial contexts. Future research should therefore incorporate additional empirical evidence and theoretical perspectives to further strengthen the discussion and situate the findings within a broader research framework.

ACKNOWLEDGMENT

We want to express our sincere gratitude to Yili Indonesia for their support in providing access to the necessary data for this research. We also extend my appreciation to the Master of Management Technology program at President University for their guidance and assistance throughout the research process.

DECLARATION OF CONFLICTING INTERESTS

We declare that there are no competing or other interests that could be perceived as influencing the results or discussion presented in this study. Some figures in this work are derived from the authors' invention patent, and all materials used are owned solely by the researcher.

REFERENCES

Adegbola, O., Ojo, E., Aborisade, D., & Adewuyi, P. (2022). An optimization approach for energy minimization and temperature control of milk pasteurization plant. *Technology*, *13*(9), 1-14. https://doi.org/10.17605/OSF.IO/7J5SE

Apriono, M., Fadah, I., Wardayanti, S. M., Niken, R., Aprillianto, B., Wahyuni, N. I., & Awwaliyah, I. (2023). The effect of financial performance and environmental sensitivity on ESG disclosure: Empirical study in agroindustrial sector. *International Journal of Applied Business and International Management*, *8*(3), 361-375. https://doi.org/10.32535/ijabim.v8i3.2531

Batuta, D., & Abd Rahman, M. (2023). Improving the quality of the chocolate production process at Wahana Interfood Nusantara Company using the DMAIC Method. *Journal of Community Development in Asia*, *6*(1), 34-45. https://doi.org/10.32535/jcda.v6i1.1955

China Mengniu Dairy Company Limited. (2024). *2024 Sustainability Report*. China Mengniu Dairy Company Limited. https://img.mengniu.com.cn/Uploads/Mnnew/File/2025/04/29/u681096cbe8503.pdf

Clean Energy Ministerial. (2020). *ISO 50001 Energy Management System Case Study*. Clean Energy Ministerial. https://www.cleanenergyministerial.org/content/uploads/2022/03/cem-em-casestudy-3m-global-1.pdf

Detzel, A., Krüger, M., Busch, M., Blanco-Gutiérrez, I., Varela, C., Manners, R., ... & Zannini, E. (2022). Life cycle assessment of animal-based foods and plant-based protein-rich alternatives: An environmental perspective. *Journal of the Science of Food and Agriculture*, *102*(12), 5098-5110. https://doi.org/10.1002/jsfa.11417

Goff, H. D. (2019). Dairy product processing equipment. In *Handbook of Farm, Dairy and Food Machinery Engineering* (pp. 245-265). Academic Press. https://doi.org/10.1016/B978-0-12-814803-7.00011-7

Hui, G. K., Ibrahim, H., Jie, L. S., Wen, L. X., Guowei, L., Baochen, L., …, & Gupta, S. (2024). Factors influencing consumer loyalty: A study in the tech industry. *Asia Pacific Journal of Management and Education,* *7*(3), 379-396. https://doi.org/10.32535/apjme.v7i3.3543

International Finance Corporation (IFC). (2007). *Environmental, health, and safety guidelines for dairy processing* (EHS guidelines) [Technical manual]. World Bank Group. https://documents.worldbank.org/curated/en/627191484196265248/pdf/111927-WP-ENGLISH-Dairy-Processing-PUBLIC.pdf

Karimidastjerd, A., Gulsunoglu-Konuskan, Z., Olum, E., & Toker, O. S. (2024). Evaluation of rheological, textural, and sensory characteristics of optimized vegan rice puddings prepared by various plant-based milks. *Food Science & Nutrition*, *12*(3), 1779-1791. https://doi.org/10.1002/fsn3.3872

Loncin, M. (2012). *Food Engineering: Principles and Selected Applications*. Elsevier.

Lukman, J. A., Oh, Z. J., Akmal, M. A. J., Alimi, M. M. T., Hakimie, M. A. A. S., Basyir, M. A. S., … Kee, D. M. H. (2024). The role of robotics-driven productivity, profit, and employee satisfaction in enhancing sustainability in the beverage industry. *Asia Pacific Journal of Management and Education,* *7*(3), 256–272. https://doi.org/10.32535/apjme.v7i3.3541

Luo, P., Cheng, Y., Wang, Z., Jin, Y., & Yang, W. (2005). Research progress in liquid-liquid rapid mixing equipment [液-液快速混合设备研究进展]. *24*(12), 1319–1326.

Mehany, T., Siddiqui, S. A., Olawoye, B., Olabisi Popoola, O., Hassoun, A., Manzoor, M. F., & Punia Bangar, S. (2024). Recent innovations and emerging technological advances used to improve quality and process of plant-based milk analogs. *Critical Reviews in Food Science and Nutrition*, *64*(20), 7237-7267. https://doi.org/10.1080/10408398.2023.2183381

Ministry of Investment and Downstream Industry (BKPM). (2023). *Indonesia Investment Guidebook 2022*. Ministry of Investment and Downstream Industry (BKPM). https://www.bkpm.go.id/id/info/pengumuman/buku-panduan-investasi-indonesia-2022

Moejes, S. N., & Van Boxtel, A. J. B. (2017). Energy saving potential of emerging technologies in milk powder production. *Trends in Food Science & Technology*, *60*, 31-42. https://doi.org/10.1016/j.tifs.2016.10.023

Mou, L., & Zhang, X. (Inventors). (2024). *High-efficiency mixing device for industrial liquid chemical raw materials* (Chinese Patent No. CN 113546535 B). China National Intellectual Property Administration. https://patents.google.com/patent/CN113546535B/zh

Oliveros, M. C. R. (2019, November). The dairy industry in southeast asia: Perspective, challenges and opportunities. In *IOP Conference Series: Earth and Environmental Science* (Vol. 372, No. 1, p. 012068). IOP Publishing. https://doi.org/10.1088/1755-1315/372/1/012068

Samimi, M., Mohammadzadeh, E., & Mohammadzadeh, A. (2023). Rate enhancement of plant growth using Ormus solution: Optimization of operating factors by response surface methodology. *International Journal of Phytoremediation*, *25*(12), 1636-1642. https://doi.org/10.1080/15226514.2023.2179014

Sharma, N., Yeasmen, N., Dube, L., & Orsat, V. (2024). Rise of plant-based beverages: A consumer-driven perspective. *Food Reviews International*, *40*(10), 3315-3341. https://doi.org/10.1080/87559129.2024.2351920

Tejaningrum, A., & Putra, A. I. (2022). Measurement of supply chain management performance using SCOR Model. *Journal of the Community Development in Asia*, *5*, 40-52. https://doi.org/10.32535/jcda.v5i3.1777

Wang, S. (Inventor). (2017). *Industrial liquid chemical raw material efficient mixing device* (Chinese Patent No. CN 107321230 A). China National Intellectual Property Administration. https://patents.google.com/patent/CN107321230A/zh

Wannasin, D., & McClements, D. J. (2023). Optimizing the appearance of plant-based foods: Impact of pigment and droplet characteristics on optical properties of model oil-in-water emulsions. *Food Biophysics*, *18*(2), 289-301. https://doi.org/10.1007/s11483-022-09771-6

Yili Industrial Group Co., Ltd. (2023). *2023 Sustainability Report* (English). Yili Group. https://www.yili.com/downloads/2023_Sustainability_Report_EN.pdf

Zhang, D., Xia, W., Zhang, J., & Xia, S. (Inventors). (2020). *Mixing and stirring device for liquid chemical raw materials* (Chinese Utility Model Patent No. CN 210278994 U). Jiangsu Huaihe Chemicals Co Ltd. https://patents.google.com/patent/CN210278994U/zh

ABOUT THE AUTHOR(S)

1st Author
Zhang Xufeng is a Master of Management in Technology student at President University, Jababeka, Indonesia, and serves as General Manager of Equipment at PT Yili Indonesia Dairy.
Email: ytnzhangxufeng@yili.com

2nd Author
Stephanus Remond Waworuntu is a senior academic and lecturer in business and management, currently serving in a leadership role at President University in Indonesia. At President University, he has been appointed Head of the Management Study Program in the Faculty of Business, overseeing curriculum, academic quality, and student development within the department.
Email: stephanus@president.ac.id
ORCID ID: https://orcid.org/0009-0001-6267-0611