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Design and Development of Dough and Cream Mixing Technology

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Abstract: *This study focused on the development and evaluation of a dough and cream mixing technology designed to address the limitations of manual and low-cost mixing systems in producing consistent, safe, and quality dough and cream outputs. Guided by the ADDIE model, the study identified the user, technical, and functional requirements of the technology based on current practices and user experiences. These requirements emphasized the need for intuitive operation, reduced user-dependent variability, controllable mixing parameters, sensor-based monitoring, automation, and standardized output quality. Using these inputs, the technology was designed and developed as a 2–3-kilogram-capacity automated prototype with a machine enclosure measuring 750 mm × 750 mm × 1500 mm and a food mixer unit measuring 545 mm × 440 mm × 882 mm. The system operates using a 220VAC power supply with a 24VDC control system and integrates a Programmable Logic Controller, Human-Machine Interface, load and safety sensors, planetary mixing mechanism, and weight-based automatic mixing time computation.*

The study employed a developmental research design using quantitative and qualitative data gathered through performance measurement tools, evaluation checklists, and user acceptability surveys. The developed technology was implemented in a controlled, safe, sanitary, and standardized testing environment at Surigao del Norte State University prior to performance evaluation. Results showed that the technology was technically feasible, economically viable, environmentally sound, politically acceptable, and socially acceptable. Evaluators recommended improvements in visibility, user-friendliness, wiring safety, structural design, durability, functionality, and sustainability through mechanical and material upgrades. Overall, the study concluded that the developed dough and cream mixing technology is suitable for domestic, educational, and small-scale food production applications, provided that its adoption is supported by simplified operation protocols, structured training, maintenance support, institutional partnerships, commercialization strategies, and intellectual property protection.

Keywords: Dough Mixing Technology, Cream Mixing System, PLC-HMI Automation, Food Processing Equipment

I. INTRODUCTION

The study entitled "Design and Development of Dough and Cream Mixing Technology" was conducted to address the need for an efficient, automated, and user-friendly mixing system for bakery and food processing applications, as dough and cream mixing directly affect texture, consistency, aeration, viscosity, gluten development, and overall product quality. Previous food engineering studies emphasized that mixing performance significantly influences rheological properties and product acceptability, while poor mixing leads to inconsistent quality, weak structure, and inefficiency, especially among small-scale producers in the Philippines who still rely on conventional manual equipment. Thus, the study developed an affordable, efficient, and adaptive mixing system using Malunggay Pandesal dough and Peanut Butter Cream for testing, integrating PLC automation, HMI operation, load-cell sensing, and intelligent mixing control to improve consistency, efficiency, safety, and usability.

Although no formal hypotheses were stated, the study assumed that PLC-HMI automation, sensor-based monitoring, automatic time computation, and intelligent control would improve mixing consistency, efficiency, safety, reliability, and user satisfaction compared with traditional systems, while also ensuring technical feasibility, economic viability,

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environmental soundness, political acceptability, and social acceptability. The review of literature established that dough mixing supports hydration, gluten formation, gas retention, and elasticity, while cream mixing supports emulsification, aeration, and consistency, with studies (Sun et al., 2023; Atudorei et al., 2023; Ghosh and Datta, 2022) showing that speed, duration, and ingredient interactions affect product quality. Existing mixers are widely used but still rely on manual control, leading to overmixing, overheating, and inconsistency, while studies (Wang et al., 2024; Kim and Park, 2021; Zhang et al., 2025) highlighted the benefits of PLCs, HMIs, and sensors for precision and automation.

The review further identified a research gap in the lack of an integrated, small-scale, user-friendly Dough and Cream Mixing Technology combining PLC-HMI control, load-cell sensing, automated timing, intelligent operation, safety mechanisms, and user-centered design. Most existing systems focus on either industrial-scale automation or individual technologies without full integration. Thus, this study developed an automated system addressing this gap, contributing to food processing innovation, supporting MSME modernization, and improving mixing consistency, operational efficiency, usability, and product quality.

II. REVIEW OF RELATED LITERATURE

A. Dough and Cream Mixing, Product Quality and Dough and Mixing Technology

Mixing is considered one of the most important stages in bakery and cream-based food production because it directly affects product texture, consistency, viscosity, aeration, and overall quality. In dough preparation, the mixing process contributes to hydration, gluten formation, gas retention, and dough elasticity, which are essential in producing bread with desirable volume and texture. According to Sun et al. (2023), the rheological properties of dough are highly influenced by mixing conditions, ingredient interactions, and mechanical energy input. Improper mixing may lead to poor gluten development, uneven dough structure, and reduced bread quality. Similarly, Atudorei et al. (2023) emphasized that mixing performance significantly affects the physical and structural properties of bakery products.

In cream processing, mixing also plays a vital role because cream products require proper emulsification, aeration, and consistency to achieve desirable texture and stability. Cream mixing involves the incorporation of air and uniform blending of ingredients to produce smooth and stable products suitable for bakery and confectionery applications. According to Ghosh and Datta (2022), controlled mixing speed and duration are necessary to maintain cream viscosity and prevent product separation. This indicates that dough and cream mixing technologies require appropriate control systems to maintain product consistency and operational efficiency.

Dough and cream mixing technologies are commonly used in households, food laboratories, bakeries, and small-scale food enterprises because of their efficiency and accessibility. However, many existing mixers still rely heavily on manual control, operator experience, and trial-and-error adjustments of mixing time and speed. These limitations may result in inconsistent product quality, overmixing, overheating, and inefficient operation. Wang et al. (2024) explained that sensor-based monitoring systems can improve mixing precision by detecting load variations and operational behavior during mixing processes. The study further emphasized that automated monitoring can help achieve more consistent product quality.

Several studies highlighted the importance of integrating adaptive and intelligent features into food mixing technologies. Modern food mixers increasingly utilize programmable control systems, sensors, and automated timing mechanisms to improve process consistency and reduce human intervention (Kim & Park, 2021; Zhang et al., 2025). These developments support the need for a more advanced Dough and Cream Mixing Technology capable of handling different food mixtures while maintaining operational stability and product quality.

The present study is related to these findings because it aims to design and develop a Dough and Cream Mixing Technology integrated with automated control, load sensing, and programmable operation. Unlike traditional mixers that depend largely on manual operation, the developed technology seeks to provide improved mixing consistency, safer operation, and better adaptability for dough and cream preparation in food processing environments.

B. Automation in Food Processing System, Human-Machine Interface, and Sensor-Based Measurement and Control

Automation plays a significant role in modern food processing because it enhances operational efficiency, productivity, precision, and product consistency. Automated food processing systems reduce manual labor, minimize process variability, and improve quality control through the use of programmable devices, sensors, and intelligent control mechanisms. According to Mohammed et al. (2025), automation technologies in food manufacturing contribute to more efficient processing operations and improved production reliability.

Programmable Logic Controllers are widely used in industrial and food processing applications because they provide accurate control of machine sequences, motors, sensors, and safety systems. PLCs are capable of executing programmed instructions that automate machine operations and ensure consistent process execution. Kim and Park (2021) stated that PLC-based food processing systems improve operational precision, minimize human error, and support process standardization. This makes PLC integration highly applicable in automated dough and cream mixing operations where timing, speed control, and consistency are essential.

Human-Machine Interface technology is also important in automated systems because it allows users to interact with the machine through graphical displays, operational controls, and real-time monitoring. HMI systems improve usability by enabling operators to monitor machine status, adjust settings, and respond to operational alerts efficiently. Sanchez-Chero et al. (2025) explained that PLC-HMI integration improves process monitoring, user interaction, and system validation in automated operations. In food processing applications, HMI technology supports user-friendly operation and improves machine accessibility for both skilled and non-technical users.

Sensor-based measurement and control systems are increasingly integrated into automated food technologies to improve accuracy and process monitoring. Sensors such as load cells, current sensors, and temperature sensors provide real-time operational data that can be used for automated decision-making and process control. Wang et al. (2024) demonstrated that current sensors can effectively monitor dough mixing conditions and detect optimal kneading performance. Similarly, Zhang et al. (2025) emphasized that automated food systems increasingly utilize sensor-based technologies to improve process efficiency and product quality.

Safety and reliability are also essential considerations in automated food machinery. Automated systems commonly incorporate emergency stop functions, overload protection, and safety interlocks to prevent equipment damage and ensure operator safety. According to de Oliveira et al. (2023), integrating safety and monitoring systems into automated food equipment enhances operational stability and reduces the risk of machine failure during continuous operation.

The present study is aligned with these technological advancements because the developed Dough and Cream Mixing Technology integrates PLC-HMI automation, load cell sensing, programmable mixing operation, and safety control mechanisms. The integration of these technologies is expected to improve mixing consistency, operational efficiency, user interaction, and machine reliability while supporting technology management innovation in food processing applications.

C. International View, Philippine Setup, and Small-Scale User-Centered Food Processing Technologies

Globally, the food processing industry continues to adopt automation, smart technologies, and intelligent control systems to improve efficiency, consistency, and productivity. Advanced food processing equipment increasingly incorporates sensors, robotics, programmable systems, and data-driven control technologies to support precision processing and quality assurance. Zhang et al. (2025) noted that modern food manufacturing systems utilize machine learning and sensor-based automation to optimize production processes and improve operational performance. Similarly, Mohammed et al. (2025) emphasized that automated food processing technologies help address labor shortages, operational inefficiencies, and quality inconsistencies in food manufacturing industries.

In developing countries, small-scale food enterprises continue to play an important role in local economic development and food production. In the Philippines, micro, small, and medium enterprises significantly contribute to employment generation and industrial productivity. According to the Philippine Statistics Authority (2022), food manufacturing

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remains one of the country's major economic sectors, with many enterprises operating at small and medium production scales. However, many local food processors still rely on conventional or semi-mechanized equipment that requires extensive manual operation and monitoring.

The Philippine government, through the Department of Science and Technology, continues to promote technology innovation and upgrading among MSMEs through programs such as the Small Enterprise Technology Upgrading Program (SETUP). This initiative supports enterprises in adopting appropriate technologies that improve productivity, product quality, operational efficiency, and competitiveness (Department of Science and Technology Region I, n.d.). Several local bakery enterprises have benefited from technological upgrading programs involving food processing equipment and automated production systems.

User-centered technology development is important in small-scale food processing because users require machines that are affordable, efficient, safe, durable, and easy to operate. Small-scale food operators often encounter challenges related to labor-intensive processing, inconsistent product quality, limited technical skills, and operational inefficiency. Therefore, food processing technologies intended for small-scale applications must be designed according to the needs, capabilities, and production requirements of end users.

The present study supports this technological direction by developing a Dough and Cream Mixing Technology intended for food processing applications. The developed technology aims to provide improved mixing performance, operational convenience, automation capability, and safety while remaining suitable for local users and small-enterprise operations. Through the integration of intelligent control systems and user-centered design principles, the study contributes to the advancement of locally appropriate food processing technologies.

D. Theoretical Framework

The study is anchored on three main theories: Systems Theory, Automation and Control Theory, and Constructivist Learning Theory. These theories collectively explain the relationship between system components, automation processes, and user interaction in the development of the Dough and Cream Mixing Technology.

Systems Theory

Systems Theory explains that a system is composed of interconnected and interdependent components that work together to achieve a common goal through the Input–Process–Output (IPO) model. In this study, the Dough and Cream Mixing Technology is viewed as an integrated system where ingredients, user inputs, sensors, PLC, HMI, motors, and control mechanisms interact to produce a unified outcome. The theory emphasizes that system efficiency depends on how well all components function together rather than individually. Thus, the proper coordination of inputs (ingredients and settings), processes (automated mixing operations), and outputs (consistent dough and cream quality) ensures improved performance, efficiency, and product consistency.

Automation and Control Theory

Automation and Control Theory focuses on the use of automatic systems, sensors, controllers, and feedback mechanisms to regulate machine operations with minimal human intervention. It explains that real-time monitoring and automatic adjustments improve accuracy, efficiency, and consistency in industrial processes. In this study, the Dough and Cream Mixing Technology uses PLC-based control and sensor systems to automate key functions such as weight measurement, mixing time control, and motor speed regulation. Through continuous monitoring and feedback, the system can adjust its operations automatically, reducing human error while improving operational safety, precision, and product quality.

Constructivist Learning Theory

Constructivist Learning Theory states that learning occurs through active engagement, hands-on experience, and interaction with tools and the environment rather than passive reception of information. It emphasizes that learners construct knowledge by directly experiencing and exploring real-world systems. In this study, users interact with the Dough and Cream Mixing Technology through the HMI interface and automated controls, allowing them to learn how the system operates through actual use. This hands-on experience enhances understanding of food processing automation, improves operational skills, and supports deeper learning of mixing technology and system functionality.

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Research Paradigm

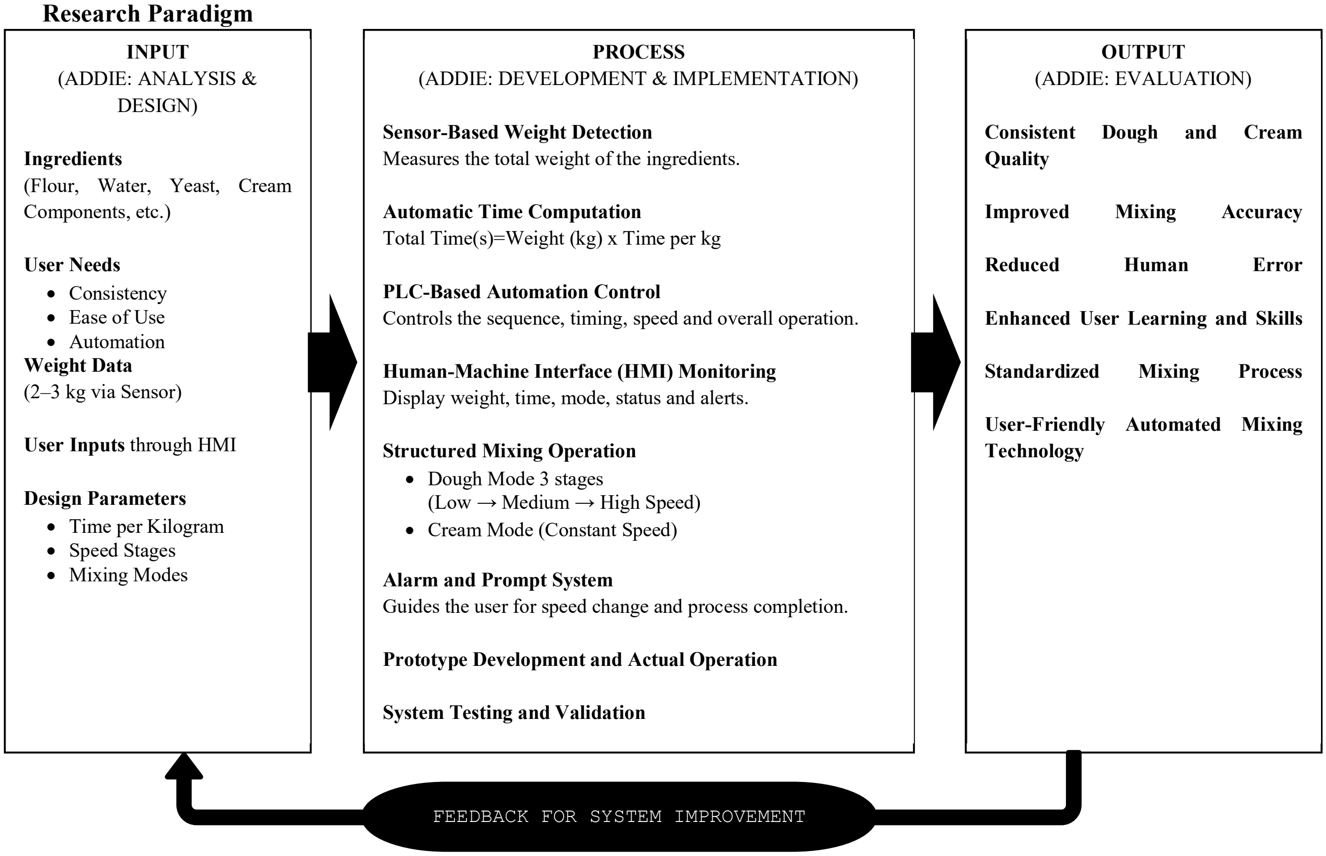

Fig. 1. Conceptual Framework of the Design and Development of Dough and Cream Mixing Technology

III. METHODOLOGY

This chapter presents the materials and equipment used, the experimental design, procedure, and statistical tools used for data analysis.

A. Research Design

This study employed a developmental research design guided by the ADDIE Framework (Analysis, Design, Development, Implementation, and Evaluation) in the development of the Dough and Cream Mixing Technology integrated with PLC, HMI, load cell sensors, and automated control systems, with quantitative methods used to assess its functionality, usability, reliability, and acceptability through testing and expert evaluation. The Analysis Phase identified key problems in manual mixing such as inconsistent product quality, labor-intensive processes, overheating, and lack of automation through literature review, observation, and interviews, which served as the basis for system requirements. The Design Phase focused on developing the system structure, including block diagrams, flowcharts, electrical layout, operational modes (Dough Mode with staged speed mixing and Cream Mode with constant speed mixing), as well as safety features, PLC-HMI integration, and calibration procedures. The Development Phase involved fabrication, wiring, programming, and integration of all components, followed by calibration and testing to ensure accuracy, stability, and safe operation. The Implementation Phase involved actual testing using Malunggay Pandesal dough and Peanut Butter Cream to evaluate mixing performance, sensor accuracy, reliability, safety, and stability under controlled conditions. Finally, the Evaluation Phase assessed the system's functionality, usability, safety, and acceptability using questionnaires

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and test results, with data analyzed through mean and standard deviation to determine overall effectiveness and areas for improvement.

B. Research Environment

This study was conducted at the Metals and Engineering Innovation Center (MEIC) CARAGA Laboratory of Surigao del Norte State University, Km. 8, Barangay Bonifacio, Surigao City, Philippines, a facility equipped for mechanical fabrication, electrical integration, automation development, and prototyping. The laboratory provided essential tools and equipment such as welding machines, machining devices, electrical testing instruments, and automation facilities used in the fabrication, assembly, wiring, programming, and integration of the Dough and Cream Mixing Technology, including the PLC, HMI, load cell sensor, relays, contactor, and motor system. Meanwhile, the implementation, operational testing, and evaluation were conducted at the Mechatronics Laboratory of SNSU Main Campus, which served as a controlled environment for actual machine operation, troubleshooting, and performance assessment. In this venue, the developed technology was tested in terms of functionality, mixing efficiency, operational stability, automation performance, safety, reliability, and usability during dough and cream mixing processes. Research environments provided the necessary facilities, equipment, and technical support essential for the successful design, development, implementation, testing, and evaluation of the study.

Highlights the map of the Metals and Engineering Innovation Center (MEIC) CARAGA Laboratory of Surigao del Norte State University as the local of the study.

C. Participants of the Study

The study involved a total of 13 respondents composed of 4 mechanical technology experts, 4 electronics and automation experts, 3 Bachelor of Hotel Management (BHM) faculty members, 1 professional baker, and 1 statistician, who collectively provided expert evaluation and assessment of the developed Dough and Cream Mixing Technology.

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D. Research Instrument

The primary research instrument was a researcher-made evaluation questionnaire designed to assess the performance, functionality, usability, safety, and acceptability of the developed Dough and Cream Mixing Technology, based on the study objectives, ADDIE Framework, related literature, and expert recommendations. It consisted of two parts: respondent profile and an evaluation checklist covering Technical Feasibility, Economic Viability, Environmental Soundness, Political Acceptability, and Social Acceptability. During testing, respondents evaluated the machine while processing Malunggay Pandesal dough for Dough Mode and Peanut Butter Cream for Cream Mode to assess its mixing performance, efficiency, and usability.

E. Gathering Procedure

The data gathering procedure followed the ADDIE Framework (Analysis, Design, Development, Implementation, and Evaluation). In the Analysis Phase, the researcher identified problems, user needs, and technical requirements in dough and cream mixing through observation, literature review, consultation, and expert discussions in food processing, automation, and mechanical systems. In the Design Phase, the overall structure and operational flow of the Dough and Cream Mixing Technology were developed, including the conceptual framework, system architecture, flowchart, block diagram, electrical layout, and operational sequence, with integration of PLC-HMI automation, load cell sensing, relay controls, safety mechanisms, and programmed mixing operations for both Dough Mode and Cream Mode to ensure efficient and controlled performance.

F. Statistical Treatment

The questionnaire utilized a Five-Point Likert Scale to determine the respondents' level of evaluation for each criterion, and it was content-validated by experts in mechanical technology, electronics and automation, food processing, and research methodology to ensure clarity, relevance, and appropriateness of the items, with necessary revisions incorporated based on their recommendations. The finalized instrument was then administered during the implementation and evaluation phase of the study to gather data on the performance and acceptability of the developed Dough and Cream Mixing Technology.

SCALE	DESCRIPTIVE RATING	INTERPRETATION
5	Excellent	The criterion is fully achieved and highly acceptable
4	Very Good	The criterion is achieved and acceptable
3	Good	The criterion is moderately achieved
2	Fair	The criterion is slightly achieved
1	Poor	The criterion is not achieved

IV. FINDINGS AND DISCUSSION

This chapter presents and discusses the results of the study based on the problems.

A. The user, technical, and functional requirements for the Dough and Cream Mixing Technology based on existing mixing practices, operational needs, and user experiences.

User requirements for domestic dough mixing technology focus on reducing human error and supporting ease of use, especially for beginners or training environments where manual judgment often leads to inconsistent dough quality. Since improper mixing can cause under- or over-developed gluten and affect product quality, users need a system that is simple, intuitive, and provides guided or assisted operation to ensure consistent results.

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Technical requirements involve controlling key mixing variables such as speed, time, hydration, and mechanical energy to achieve proper dough development. Studies show that these parameters greatly affect dough consistency, and that real-time indicators like motor load or torque can help determine optimal mixing conditions. Therefore, the system requires adjustable speed and timing control, and ideally basic sensing capability to monitor mixing load for more accurate and stable performance.

Functional requirements define how the system operates to achieve consistent results, emphasizing automation and process control. The mixer should be able to follow preset or programmed modes, automatically regulate mixing time and speed, and stop at optimal dough development to avoid overmixing. With these features, the system ensures consistent product quality while improving efficiency and supporting user learning in both household and training applications.

B. Specifications of the Developed Dough and Cream Mixing Technology

Table 1. Specifications of the Developed Dough and Cream Mixing Technology

Specification Area	Description
Power Supply	The machine operates using a 220VAC power supply.
Control Voltage	The control system uses 24VDC for sensors, switches, PLC, and HMI components.
Motor Rating	The machine is driven by an electric motor and gear system; however, the exact motor rating such as horsepower, wattage, rpm, voltage, current, or torque was not specified in the provided data.
Automation Control	The machine is controlled by a Programmable Logic Controller (PLC) and operated through a Human-Machine Interface (HMI). The HMI allows selection of dough or cream mode, start/stop operation, tare or zero function, and monitoring of weight, time, speed stage, and system status.
Sensor System	The system includes a load cell, bowl guard switch, bowl position switch, speed selector proximity sensor, emergency stop, and main power latch. The load cell detects ingredient weight, while the other sensors and switches support safe and controlled operation.
Mixing Capacity	The mixing bowl is designed for a 2–3 kg capacity, suitable for household and small-scale food processing applications.
Mixing Mechanism	The machine uses a planetary mixing mechanism driven by an electric motor and gear system. In dough mode, it follows a three-stage mixing process involving low, medium, and high speed. In cream mode, it operates at a constant speed.
Machine Materials / Structural Components	The machine consists of a rigid frame enclosed in a protective cabinet with an access door for loading, cleaning, and maintenance. It includes a machine enclosure, support frame, control panel, PLC housing, safety structure, wheels for mobility, jacking bolts for stability, food mixer unit, mixing bowl, load cell support, and bowl position handwheel.
Energy Efficiency Feature	The machine automatically computes mixing time based on the detected ingredient weight. This feature helps standardize

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operation, reduce human error, prevent unnecessary mixing time, and support more efficient use of energy during operation.

Table 1 shows the developed Domestic Dough and Cream Mixing Technology is an automated machine for household and small-scale food processing with an enclosure size of 750 mm × 750 mm × 1500 mm and mixer unit size of 545 mm × 440 mm × 882 mm, operating on 220VAC with a 24VDC control system integrating a PLC and HMI for automated control and user interface, using a planetary mixing mechanism driven by an electric motor and gear system with a 2–3 kg capacity bowl and load cell for weight detection, where dough mixing follows low–medium–high speed stages while cream mixing runs at constant speed, and safety features such as load cell monitoring, safety switches, emergency stop, and automatic time computation enhance consistency, reduce errors, and improve efficiency.

C. Implementation, Management, and Maintenance of Domestic Dough and Cream Mixing Technology

Implementation

The developed domestic dough and cream mixing technology was implemented in a controlled testing environment at Surigao del Norte State University, serving as the transition from fabrication to formal evaluation. The machine was installed in a designated area prepared for safe, sanitary, and standardized testing, where work surfaces, utensils, and food-contact parts were cleaned and sanitized. Safety protocols were observed, including inspection of electrical connections, stable machine placement, and careful operation by the researcher without contact with moving parts. Standardized procedures were used, including fixed formulations, batch sizes, and mixing methods for dough and cream, ensuring consistent testing conditions. Dough output was assessed based on uniformity, smoothness, elasticity, and absence of dry flour, while cream output was evaluated in terms of smoothness, stability, and even blending. Preliminary operation tested mechanical readiness, stability, vibration, noise, motor performance, and capacity, confirming suitability for formal evaluation. Ease of use, affordability, and practical operation for domestic and small-scale use were also observed, showing its suitability for households, livelihood groups, educational settings, and microenterprises. In field application, the machine may reduce manual labor, improve consistency, and support small-scale food production, provided users follow safety and sanitation practices, proper handling, and cleaning procedures. Continued use depends on producing consistent, acceptable dough and cream quality suitable for domestic and commercial use.

Management

The machine operates as a semi-autonomous system controlled through a Human-Machine Interface (HMI), where users select dough or cream mode, load ingredients, and start the process after safety confirmation. The Programmable Logic Controller (PLC) governs the entire operation by processing load cell sensor data to determine ingredient weight and compute mixing time. It executes programmed mixing cycles: three-stage speed (low, medium, high) for dough and constant speed for cream, while displaying real-time status such as weight, speed, and time. This automated system reduces human error, ensures consistency, and supports standardized operation suitable for households, training institutions, and small-scale production.

Maintenance

Maintenance includes preventive and corrective procedures covering mechanical, electrical, and control systems. Mechanical maintenance involves cleaning and inspecting the mixing bowl, gears, motor, and structural components to prevent wear and buildup, as well as checking alignment and stability systems. Electrical and control maintenance includes calibration of load cell sensors, inspection of PLC and HMI functions, and checking safety systems such as emergency stop and interlocks. Since the system uses 220VAC and 24VDC power, proper grounding and electrical integrity are essential. Long-term sustainability is supported through proper user training, routine cleaning, replaceable parts, and availability of technical support for repairs and servicing.

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D. Performance of the Domestic Dough Mixing Technology

Table 2. Performance of the Domestic Dough Mixing Technology Perform in terms of Technical Feasibility

Statement	Mean	SD	Description
1. The dough mixing system effectively performs uniform mixing suitable for bread production.	5.00	0.00	Strongly Agree
2. The design integrates mechanical, electrical, and control components in a reliable manner.	4.75	0.45	Agree
3. The system uses locally available materials and components.	4.42	0.51	Agree
4. The machine is easy to operate for small-scale bakery workers.	4.67	0.49	Agree
5. The system demonstrates consistent performance during trial runs.	4.75	0.45	Agree
6. Safety features (guards, switches, electrical protection) are adequate and functional.	4.42	0.51	Agree
7. The system is easy to assemble, disassemble, and maintain.	4.50	0.52	Agree
8. The design meets basic food safety and sanitation requirements.	4.50	0.52	Agree
Average	4.75	0.45	Agree

The results in table 2 indicate that respondents generally perceived the system as technically viable for small-scale bakery operations, with the highest rating for its ability to achieve uniform mixing for bread production (M = 5.00, SD = 0.00), followed by strong ratings for integration of components (M = 4.75, SD = 0.45), consistent performance (M = 4.75, SD = 0.45), ease of operation (M = 4.67, SD = 0.49), ease of assembly and maintenance (M = 4.50, SD = 0.52), and compliance with food safety standards (M = 4.50, SD = 0.52), while the use of locally available materials and adequacy of safety features both received slightly lower but still positive ratings (M = 4.42, SD = 0.51), indicating overall acceptability with minor areas for improvement.

Table 3. Performance of the Domestic Dough Mixing Technology Perform in terms of Economic Viability

Statement	Mean	SD	Description
1. The overall cost of the dough mixing system is significantly lower than comparable commercial mixers.	4.33	0.65	Agree
2. The system provides acceptable performance relative to its cost.	4.50	0.52	Agree
3. Maintenance and operating costs are affordable for small and micro-scale bakeries.	4.42	0.67	Agree
4. The system reduces labor time and effort in dough preparation.	4.75	0.45	Agree
5. The system has potential for local fabrication and commercialization.	4.50	0.52	Agree
6. Replacement parts are inexpensive and readily available.	4.00	0.74	Agree
Average	4.50	0.52	Agree

As shown in the table 3 the results suggest that the system is generally perceived as cost-effective and financially practical for small and micro-scale bakery operations, with the highest rating for reducing labor time and effort in dough

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preparation (M = 4.75, SD = 0.45), followed by acceptable performance relative to cost (M = 4.50, SD = 0.52) and strong potential for local fabrication and commercialization (M = 4.50, SD = 0.52), while moderate ratings were given to lower overall cost than commercial mixers (M = 4.33, SD = 0.65), affordability of maintenance and operating expenses (M = 4.42, SD = 0.67), and return on investment (M = 4.33, SD = 0.65), and the lowest rating on availability and affordability of replacement parts (M = 4.00, SD = 0.74).

Table 4. Performance of the Domestic Dough Mixing Technology Perform in terms of Environmental Soundness

Statement	Mean	SD	Description
1. The system consumes minimal electrical energy during operation.	4.25	0.75	Agree
2. The design minimizes material waste during fabrication.	4.50	0.52	Agree
3. The system produces low noise and vibration levels.	4.08	0.67	Agree
4. Materials used are durable and environmentally acceptable.	4.67	0.49	Agree
5. The system generates minimal waste during operation and cleaning.	4.83	0.39	Agree
6. The machine promotes efficient use of raw materials (flour, water, additives).	4.67	0.49	Agree
Average	4.50	0.52	Agree

The results in table 4 indicate that the system is generally perceived as environmentally responsible and sustainable, with the highest rating for minimal waste generation during operation and cleaning (M = 4.83, SD = 0.39), followed by the use of durable and environmentally acceptable materials (M = 4.67, SD = 0.49) and efficient use of raw materials such as flour and water (M = 4.67, SD = 0.49), while additional positive evaluations were given to minimized fabrication waste (M = 4.50, SD = 0.52) and low electrical energy consumption (M = 4.25, SD = 0.75), and the lowest rating for noise and vibration levels (M = 4.08, SD = 0.67), indicating overall environmental acceptability with minor concerns on operational disturbance.

Table 5. Performance of the Domestic Dough Mixing Technology Perform in terms of Political Acceptability

Statement	Mean	SD	Description
1. The project supports DOST programs on technology innovation and local manufacturing.	4.75	0.45	Agree
2. The system contributes to the development of small and medium enterprises (SMEs).	4.67	0.49	Agree
3. The project aligns with national goals on food security and livelihood generation.	4.67	0.49	Agree
4. The technology can be adopted by public training institutions (e.g., TESDA, SUCs).	4.58	0.51	Agree
5. The project complies with relevant standards and regulatory requirements.	4.67	0.49	Agree
Average	4.67	0.49	Agree

The results indicate table 5 that the domestic dough mixing technology is generally politically acceptable and aligned with government priorities, with the highest rating for supporting government innovation and local manufacturing programs (M = 4.75, SD = 0.45), followed by contributions to SME growth, food security, and livelihood generation (M

= 4.67, SD = 0.49), compliance with standards (M = 4.67, SD = 0.49), and potential adoption in training institutions (M = 4.58, SD = 0.51), indicating strong alignment with policy, education, and local enterprise development.

Table 6. Performance of the Domestic Dough Mixing Technology Perform in terms of Social Acceptability

Statement	Mean	SD	Description
1. The system addresses the needs of small-scale bread producers and community bakeries.	4.83	0.39	Agree
2. The machine is user-friendly even for operators with limited technical background.	4.75	0.45	Agree
3. The system improves working conditions by reducing physical strain.	4.83	0.39	Agree
4. The technology is culturally acceptable and appropriate for local bakery practices.	4.83	0.39	Agree
5. The system has potential to generate employment or livelihood opportunities.	4.58	0.51	Agree
6. Users express willingness to adopt and recommend the technology.	4.92	0.29	Agree
Average	4.79	0.21	Agree

The results in table 6 indicate that the domestic dough mixing technology is highly acceptable to users, with an overall mean of 4.79 (SD = 0.21), showing strong willingness to adopt and recommend it (M = 4.92, SD = 0.29), high agreement on its effectiveness in addressing small-scale baking needs and reducing physical strain (M = 4.83, SD = 0.39), user-friendliness (M = 4.75, SD = 0.45), and contribution to livelihood opportunities (M = 4.58, SD = 0.51).

V. CONCLUSION

The dough mixing technology should be designed to minimize user-dependent variability by integrating intuitive controls, measurable process parameters, and automated features such as preset programs, real-time feedback, and adaptive shutoff mechanisms to ensure consistent dough quality and support skill development in domestic and training environments. It is engineered as a 2–3 kilogram capacity system with appropriate dimensions, power supply, transmission mechanism, and food-safe materials, making it safe, durable, and efficient for domestic and small-scale applications. Its technical specifications show suitability for dough and cream preparation through automation, safety control, standardized mixing, and practical capacity for consistent performance. The implementation, management, and maintenance features indicate that the technology is operationally viable, user-friendly, safe, and suitable for use and commercialization in households, training institutions, livelihood groups, and microenterprises. It is generally acceptable based on TAP-TEEPS evaluation in terms of technical feasibility, economic viability, environmental soundness, political acceptability, and social acceptability. Effective adoption requires proper operational guidelines, structured training, strong maintenance systems, and institutional commercialization strategies supported by partnerships, demonstrations, and intellectual property protection. Further improvement should focus on enhancing usability and visibility, strengthening safety features (especially wiring and structure), and improving overall functionality, durability, and sustainability through mechanical and material upgrades.

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