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Automatic Mixing Processor for Beverages

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Abstract

This graduate project study developed, constructed, and evaluated an Automatic Mixing Processor for Beverages designed to overcome inefficiencies in traditional beverage preparation that rely on separate mixing and heating appliances. The device integrates a planetary mixing mechanism driven by an AC motor, interchangeable attachments (wire whisk, paddle, and frother), and an induction-compatible pot with built-in induction heating for simultaneous mixing and precise temperature control. A descriptive-developmental research design guided by an input-process-output framework was employed. Materials included stainless-steel housings, planetary gear, belt-and-pulley system, and safety features. The prototype was fabricated, assembled, and tested for performance across beverage types and volumes. Fifty kitchen staff from cafés and restaurants in Kidapawan City evaluated the device after hands-on demonstration using a validated five-point Likert-scale questionnaire assessing design, functionality, convenience, usability, and safety. Performance results showed the paddle and frother attachments achieved highly reliable mixing and frothing, while the wire whisk performed best at higher liquid volumes (around 1500 mL) with controlled speeds to avoid splashing. Acceptability ratings were high overall, ranging from 4.42 (design) to 4.53 (safety). The study concludes that the multifunctional appliance successfully combines automated mixing and induction heating, delivering consistent product quality, reduced labor, space savings, and improved safety for small- to semi-large-scale use. Recommendations include enhanced ventilation, wheeled mobility, longer power cord, protective lid, pouring features, programmable controls, and long-term durability testing. The research aligns with SDG 4 (Quality Education), SDG 7 (Affordable and Clean Energy), SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation and Infrastructure), and SDG 12 (Responsible Consumption and Production). It advances technological, socio-economic, educational, and environmental sustainability by promoting energy-efficient automation, supporting food-service productivity and culinary instruction, and reducing resource waste through multifunctional design.

Keywords: Acceptability; Automated Stirring; Automatic Mixing Processor; Beverage Preparation; Induction Heating; Planetary Mixing; Self-Stirring Technology

1. Introduction

Mixing is essential in beverage preparation, but traditional methods remain inefficient and inconsistent. Single-purpose tools such as blenders for mixing and stoves for heating require multiple devices, increasing space use, time, and safety risks (Centers for Disease Control and Prevention, 2020). Induction technology provides precise, energy-efficient heating (U.S. Department of Energy, 2022), but lacks integrated automated mixing. The developed Automatic Mixing Processor for Beverages addresses these limitations by combining planetary mixing with induction heating in one appliance for consistent, hands-free preparation of hot and cold beverages, sauces, and semi-liquid foods.

Automation in beverage systems using PLC and SCADA improves accuracy, efficiency, and productivity while reducing labor and errors in batch processes involving sensors, pumps, and motors (Shivankar et al., 2021). Self-stirring mechanisms, such as those in auto-stir thermos designs with battery-powered blades, eliminate manual stirring for powdered or layered drinks while retaining temperature (Usoff et al., 2022). Lithium-ion batteries support portable, wireless appliances through high energy density and rechargeability, though they require management systems for safety (Schumm, 2024). AC motors remain common in kitchen mixers for their reliability, torque, and cost-effectiveness despite emerging BLDC alternatives (Nayak & Shivarudraswamy, 2022). Controlled mechanical stirring in automatic beverage mixers enhances consistency for small businesses (Baca López & Santana Ruiz, 2022). Speed control techniques including PI, fuzzy logic, and sliding mode methods improve precision under varying loads. Intelligent control systems coordinate mixing and heating for uniform quality and reduced human intervention. Planetary mixing mechanisms, with rotation and orbital motion, eliminate dead zones and ensure thorough blending, with advances in epi-hypocyclic designs further improving homogeneity (Alimov et al., 2025). Stand mixers provide modular, controlled mixing that reduces physical effort (Nielsen & Arlitt, 2022). Induction heating achieves up to 90% efficiency, rapid response, and safety by generating heat only in ferromagnetic cookware. Coffee preparation requires precise ratios for consistency amid growing specialty demand (Harvard T.H. Chan School of Public Health, n.d.). Functional beverages need uniform reconstitution to avoid lumping and ensure sensory quality (Kaur et al., 2024), with automation improving standardization (Botrista, 2023). Cocktail science emphasizes balance, temperature, and dilution (Bartenders Business, 2022). Container design prioritizes ergonomics, stability, and sustainability (Pinthanon et al., 2025). Stainless steel offers durability, corrosion resistance, and hygiene for food-contact parts. Energy-efficient appliances emphasize convenience, ease of cleaning, and reduced maintenance (Olatunde et al., 2024). User convenience through simplified controls and automation supports accessibility (Olatunde et al., 2024). Customer satisfaction in coffee shops depends on product quality, convenience, and safety. Induction systems support cleaner cooking and renewable integration (Paudel et al., 2023; Altouni et al., 2022). Rheology of water- and milk-based chocolate beverages affects viscosity, torque, and mixing performance (Barišić et al., 2023). Wire whisk attachments produce better foam stability and homogeneity than paddles (Petrozzi, 2022; Chen et al., 2022). Impeller placement and clearance critically influence homogeneity, with insufficient immersion creating dead zones especially at low volumes (Jiang et al., 2022).

Locally, the study targets cafés and restaurants in Kidapawan City where kitchen staff prepare beverages under space and labor constraints. Nationally, it aligns with needs in Philippine food service and home economics education for efficient, safe appliances. Globally, rising demand for specialty coffee, functional beverages, and craft cocktails requires consistent preparation amid labor shortages and quality expectations (Harvard T.H. Chan School of Public Health, n.d.; Kaur et al., 2024; Bartenders Business, 2022).

The study is grounded in automation of food processing to overcome manual inefficiencies, waste, and low productivity through uniformity and reduced intervention. Multifunctionality integrates stand-mixer capabilities with induction cooking. Ergonomics prioritizes user comfort, safety, and intuitive design to support acceptability. The conceptual model follows an input-process-output framework: inputs of ideas, references, materials, and tools; processes of planning, designing, fabricating, testing, revising, and evaluating; and output of the Automatic Mixing Processor for Beverages that addresses multitasking, space-saving, injury prevention, and cost reduction. Existing devices offer either self-stirring (Taylor, 1989, U.S. Patent No. 4,967,939; Jeong, 2014, KR20140077084A), modular mixing (Mao, 2022, CN216293831U; Danijel et al., 2013, EP2550905A1; Eklind & Sa, 2004, US7695184B2; Ambrose et al., 2020, U.S. Patent No. 10,799,072 B2), or induction heating with timers (Kim et al., 2024, U.S. Patent No. 12,013,130 B2), but none combine automated planetary mixing with interchangeable attachments, multi-speed control, induction cooking, and timing in a single compact unit suitable for small- to semi-large-scale use. Gaps include limited reach of mixing elements at low volumes, lack of simultaneous heating and mixing, and insufficient ergonomic and safety integration for commercial and educational settings. The present innovation fills these gaps by providing a hands-free, multifunctional appliance that improves efficiency, consistency, and safety.

The study aligns with SDG 4 (Quality Education) by serving as instructional material in Home Economics and Culinary programs; SDG 7 (Affordable and Clean Energy) through energy-efficient induction heating that reduces waste heat and open-flame risks; SDG 8 (Decent Work and Economic Growth) by lowering labor intensity and improving productivity in small cafés and restaurants; SDG 9 (Industry, Innovation and Infrastructure) via technological innovation in kitchen automation; and SDG 12 (Responsible Consumption and Production) by reducing the need for multiple appliances, minimizing waste from inconsistent mixing, and promoting durable, hygienic materials.

The research contributes to technological sustainability through integrated automation that enhances process efficiency and product uniformity. It supports socio-economic sustainability by enabling small food-service businesses to maintain quality with reduced labor and space requirements. Educational sustainability is advanced by providing a practical tool for teaching modern cooking technology. Environmental sustainability benefits from induction heating's high efficiency and elimination of combustion pollutants, while public-health sustainability is promoted through safer operation that reduces burn and spillage risks.

2. Material and methods

2.1 Research Design

A descriptive–developmental research design was adopted. The developmental component followed the Input–Process–Output framework drawn from General Systems Theory to guide planning, design, fabrication, testing, revision, and final evaluation of the Automatic Mixing Processor for Beverages. The descriptive component was used to document existing conditions in beverage preparation and to assess the functionality and acceptability of the completed device.

2.2 Locale of the Study
The device was designed and fabricated at Boragay Street, Kidapawan City. Evaluation activities were conducted at selected cafés and restaurants within Kidapawan City, North Cotabato, specifically Robata, Tonette, Hillside Kopi House and Ihaw-ihaw, Bistro La'Camille, Sudapin Coffee, and AJ Ji-Time Hotel and Restaurant.

2.3 Respondents of the Study
Respondents comprised 50 kitchen staff members who regularly prepare and serve food and beverages. The distribution was eleven from Robata, ten from Tonette, two from Hillside Kopi House and Ihaw-ihaw, four from Bistro La'Camille, thirteen from Sudapin Coffee, and ten from AJ Ji-Time Hotel and Restaurant Kidapawan.

2.4 Sample and Sampling Procedure
The sample consisted of the 50 kitchen workers identified above who were actively engaged in beverage preparation at the participating establishments in Kidapawan City. These individuals were selected on the basis of their direct involvement in the relevant work tasks.

2.5 Research Instrument
A researcher-developed questionnaire assessed the level of acceptability of the Automatic Mixing Processor for Beverages across five dimensions: design (14 items), functionality (10 items), convenience (9 items), usability (10 items), and safety (10 items). Responses were recorded on a five-point Likert scale ranging from 5 (Highly Acceptable) to 1 (Not Acceptable). Questionnaire validation confirmed high clarity of instructions and items, logical organization, relevance and sufficiency of items, attainment of objectives, and appropriateness of the rating scale, yielding an overall mean of 4.77 and a rating of Highly Valid.

2.6 Data Gathering Procedure
A formal request letter was first sent to the owners and managers of the participating restaurants and cafés seeking permission to conduct the study. After approval was obtained, the researcher personally demonstrated the device, allowed respondents hands-on experience with it, administered the questionnaire, provided necessary explanations, and collected the completed instruments immediately. Data were subsequently tallied for computation of weighted means.

2.7 Data Analysis Techniques
Descriptive statistics consisting of frequency counts and weighted means were applied to determine the level of functionality and acceptability of the Automatic Mixing Processor for Beverages with respect to design, functionality, convenience, usability, and safety.

3. Results and Discussion

3.1 Design and Construction
The device was successfully fabricated using stainless-steel housings, a planetary gear drive head, belt-and-pulley transmission, an AC motor, interchangeable whisk, paddle, and frother attachments, an induction unit, and an induction-compatible pot with retainer ring. Assembly integrated electrical controls, a rotary power switch, speed control, and safety lock. Testing with water and beverage ingredients confirmed simultaneous mixing and heating capability. Revisions addressed pitcher durability, stirring-rod length, and expansion from pure stirring to multifunctional mixing plus induction cooking.
The resulting prototype provides an ergonomic, multi-purpose appliance that automates mixing, aeration, and heating. Planetary action combined with induction heating yields uniform beverage quality while supporting commercial and household use, reducing labor, and enabling consistent results.

3.2 Performance with Wire Whisk Attachment
Performance trials with the wire whisk showed variable reliability. Powdered juice achieved a mean rating of 3.00 (Highly Reliable) across three trials. Hot chocolate averaged 2.00 and black coffee 1.00, with overall reliability rated as Reliable. Success improved at higher volumes (1500 mL) where the whisk reached the bottom, but lower volumes left undissolved particles. Speed had to be limited to levels 3–4 to prevent splashing.
Mixing homogeneity depends on impeller immersion and flow coverage. Higher liquid volumes improved contact and dissolution, consistent with findings that inadequate clearance creates dead zones and poor particle suspension, particularly at low volumes (Jiang et al., 2022). Operational practice therefore requires volume-aware speed regulation to balance thoroughness and safety.

3.3 Performance with Paddle Attachment

The paddle attachment produced highly reliable results for hot chocolate across 500 mL, 1000 mL, and 1500 mL batches, achieving a mean rating of 3.00 (Highly Reliable) with all three trials successful. Higher volumes enhanced mixing efficiency, yet speeds above level 3 caused splashing of hot liquid.

The paddle proved well suited to particle-laden, higher-viscosity mixtures. Viscosity differences between water and milk bases influence flow behavior and torque demand (Barišić et al., 2023). Moderate speeds therefore optimize homogeneity while preserving safety.

3.4 Performance with Frother Attachment

Frother trials on coffee mixtures yielded a mean rating of 3.00 (Highly Reliable). Stable, long-lasting foam formed only at the highest speed (level 6); lower speeds produced transient bubbles that collapsed.

Adequate shear force and aeration are essential for foam stability. Higher agitation intensity generates the small, homogeneous bubbles required for durable foam (Petrozzi, 2022; Chen et al., 2022). The frother therefore performs best under high-speed settings for coffee-based beverages.

3.5 Acceptability in Terms of Design

Overall design acceptability averaged 4.42 (Acceptable). Highest ratings were given to the tilting overhead arm with locking system (4.62), ergonomic design (4.60), speed range and control accessibility (4.58), and food-grade materials and tabletop suitability (4.50). The 3-meter extension cord scored lowest at 3.44 (Moderately Acceptable).

Ergonomic features and secure locking enhance comfort and safety during repeated use (Guo et al., 2024). Food-grade materials support hygiene, while accessible controls and digital indicators improve usability (Phuong, 2023). Cable management and structural rigidity remain areas for refinement to increase workplace flexibility (Fatah et al., 2022).

3.6 Acceptability in Terms of Functionality

Functionality averaged 4.52 (Highly Acceptable). Induction cooking effectiveness and even heating both scored 4.62; consistent mixing across ingredients scored 4.60; simultaneous multi-function operation scored 4.56; and handling of liquid and semi-solid mixtures scored 4.58.

Induction heating efficiency underpins consistent thermal performance (Yang et al., 2024). Reliable mixing across viscosities confirms appropriate impeller and motor design (Jadidi et al., 2023; Guo et al., 2024). Multifunctionality aligns with trends in automated kitchen equipment (Kumar et al., 2024; Phuong, 2023).

3.7 Acceptability in Terms of Convenience

Convenience averaged 4.49 (Acceptable). Touch-screen and soft-button controls scored 4.60; reduction of multiple appliances, secure arm locking, real-time monitoring, and easy storage all scored 4.54–4.56; hands-free operation scored 4.50. Extension-cord access scored 4.22.

Integration of functions and hands-free operation reduce physical effort and equipment clutter (Kumar et al., 2024). Responsive controls and digital monitoring support accurate preparation (Phuong, 2023; Yang et al., 2024). Compact storage aids space-constrained kitchens (Fatah et al., 2022).

3.8 Acceptability in Terms of Usability

Usability averaged 4.52 (Highly Acceptable). Clear labels and digital display scored 4.66; induction cooktop convenience scored 4.60; attachment locking and consistent results with minimal adjustment scored 4.56; 220 V compatibility and industry suitability scored 4.52. Interchangeable attachments scored 4.30.

Clear interfaces minimize user error. Secure locking and precise controls enable reliable, low-effort operation (Guo et al., 2024; Phuong, 2023). Versatility across hot beverages and semi-liquids expands practical utility (Jadidi et al., 2023; Lu et al., 2022; Kumar et al., 2024).

3.9 Acceptability in Terms of Safety

Safety averaged 4.53 (Highly Acceptable). Automatic shut-off after the preset timer scored 4.78; food-contact materials and high-temperature resistance scored 4.64; safe-to-touch handles and accidental-activation prevention scored 4.60. Glass-ceramic surface coolness scored 4.20.

Automatic shut-off and thermal protection reduce overheating risk (Yang et al., 2024). Heat-resistant, food-safe materials and stable construction support continuous commercial use (Fatah et al., 2022; Kumar et al., 2024). Enclosed electrical components and absence of open flame further enhance operational safety (Lu et al., 2022).

4. Conclusion & Recommendations

The Automatic Mixing Processor for Beverages was successfully designed, constructed, and evaluated. Performance testing confirmed reliable mixing and simultaneous induction heating across wire-whisk, paddle, and frother attachments, with optimal results dependent on volume, speed, and attachment selection. Acceptability ratings were high across design, functionality, convenience, usability, and safety, demonstrating that the integrated planetary-mixing and induction-heating system effectively addresses inefficiencies of traditional multi-appliance preparation while meeting user requirements for consistency, ease of use, and safety in small- to semi-large-scale food-service settings.

Ventilation should be optimized by relocating the exhaust near the induction fan; a wheeled pedestal with safety locks should be added for mobility; the power cord should be lengthened for greater workstation flexibility; future iterations may explore solar-assisted heating; a pouring spout or transfer mechanism and a protective lid should be fitted to the vessel; programmable controls and refined speed settings should be incorporated; and long-term durability testing under continuous commercial use is advised.

5. Compliance with ethical standards

The authors affirm that no conflicts of interest exist in relation to this study. The research was conducted in accordance with accepted ethical principles for human-participant research, including obtaining informed consent, ensuring voluntary participation, allowing participants to withdraw at any stage without consequence, and protecting participant confidentiality through anonymous, secure, and aggregated data management. Because the study examined psychological well-being, all research procedures were non-invasive and implemented with appropriate measures to reduce the risk of discomfort. Participants were informed of available support services should the need arise. Furthermore, the necessary institutional approvals were obtained for the administration of the research instruments and access to relevant academic records.

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