



DESIGN AND EXPERIMENTAL ANALYSIS OF A BI-MODAL TEMPERATURE-CONTROLLED OILSEED EXTRACTION UNIT FOR HOUSEHOLD USE

Gyimah, G. K.¹, Kwakye-Boateng, P.², and Sagoe, F.³

^{1, 2 & 3} *Department of Mechanical Engineering, Faculty of Engineering, Accra Technical University, Accra, Ghana.*

³*Egypt-Japan University of Science and Technology, Alexandria, Egypt.*

gkgyimah@atu.edu.gh

ABSTRACT

Purpose: This study aims to design, develop, and evaluate the performance of a compact dual-mode (hot and cold) oilseed extraction machine intended for household use. The specific objectives are: to design a dual-mode oilseed extraction unit that integrates both hot and cold pressing capabilities for domestic application; to fabricate a functional prototype using food-grade, durable, and cost-effective materials; and to evaluate the machine's performance in terms of oil yield, extraction efficiency, and thermal regulation across different oilseeds.

Design/Methodology/Approach: The research adopted an applied engineering design methodology. It involved a comprehensive literature review, CAD-based conceptual modelling, prototype fabrication, and performance evaluation. Design criteria included energy efficiency, food-grade material selection, thermal regulation, and ergonomic suitability. Experimental trials were conducted on three oilseeds, groundnut, soybean, and sunflower, under varying thermal conditions to assess the machine's yield and operational effectiveness.

Research Limitation: The machine was tested under controlled laboratory conditions with selected seed types. Broader trials across diverse home environments and a wider range of oilseeds would be required to generalise performance outcomes universally.

Findings: Results indicate that the developed machine effectively extracts oil yields of 250 ml (groundnut), 100 ml (soybean), and 220 ml (sunflower) per batch, affirming its viability for home-based oil production. The dual-mode functionality ensures nutrient retention in cold-pressed oils and improved yield under heated extraction, supporting both health and efficiency goals.

Practical Implication: The device empowers households to produce fresh, unrefined, and nutrient-rich oils, reducing reliance on commercially processed alternatives. Its user-friendly design and energy-conscious features make it suitable for widespread domestic applications.



Social Implications: By enabling small-scale oil processing, the technology contributes to local food sovereignty, lowers household expenses, and supports climate-conscious living. It has the potential to reduce socio-economic disparities related to access to healthy cooking oils.

Originality and Value: This study contributes novel insights into decentralised oilseed processing technologies. It bridges the gap between sustainable food practices and engineering innovation, offering a practical model for future research and development in green, home-based agro-processing systems.

Keywords: *Hot and cold pressing. mechanical pressure. oil extraction. oil press machine. seed processing*

INTRODUCTION

Oilseed extraction has undergone a significant evolution, transitioning from traditional manual techniques to advanced mechanical and thermal systems. Historically, rudimentary methods such as stone pressing and grinding were commonplace, particularly in rural settings. While these methods provided accessibility and simplicity, they were often labour-intensive, inefficient, and yielded suboptimal oil quality. The rise of industrial solvent extraction technologies, notably those using hexane, marked a leap in yield optimisation. However, these processes often entail environmental and health trade-offs due to chemical residues and high energy requirements (Kumar et al., 2017). As such, the debate between efficiency and sustainability continues to shape the oilseed processing industry.

In recent years, increasing awareness of food safety, environmental concerns, and the nutritional value of minimally processed oils has revitalised interest in cold pressing. This method, which avoids high temperatures and solvents, better retains bioactive compounds such as antioxidants, essential fatty acids, and vitamins (Abedinzadeh et al., 2023; Grajzer et al., 2020a). It is thus regarded as a healthier and more environmentally friendly alternative. Cold-pressed oils are particularly appealing to consumers seeking organic, unrefined food products. Nonetheless, this growing demand has not been matched by technological innovation at the domestic level. Most commercially available oilseed presses are either industrial-scale machines or small-scale devices that are inefficient, costly, or poorly adapted to household contexts (Mary, 2022).

Despite the expanding market for household oilseed presses, adoption remains low. This is largely attributed to the limited accessibility of efficient, compact, and affordable



machinery that supports both hot and cold extraction. Current domestic equipment often lacks user-friendliness, operates at low yields, and fails to offer sufficient control over pressing parameters (Hudzenko et al., 2023). These limitations discourage self-production of cooking oils at home, resulting in continued reliance on refined, mass-produced alternatives that may lack nutritional integrity and increase exposure to chemical additives.

In response to this technology gap, this study proposes the design and fabrication of a dual-mode oilseed extraction machine suitable for household use. The dual-mode capability, offering both hot and cold extraction options, addresses the need for versatility across a variety of seed types and consumer preferences. The research aims to develop a sustainable, efficient, and ergonomically friendly machine that balances affordability with performance. Key design considerations include material safety, energy efficiency, thermal regulation, ease of maintenance, and compact form factor (PengFei et al., 2015).

This initiative aligns with broader objectives in sustainable food systems and decentralised processing technologies. It promotes dietary autonomy by allowing users to control oil quality and production methods (*Delivering a New, Efficient and Biobased Plant Oil and Protein Extraction System*, 2021). Moreover, localised oil extraction has the potential to reduce the carbon footprint associated with large-scale distribution, packaging, and storage of commercial oils (Salvador et al., 2022). The machine also serves as a tool for food sovereignty, empowering individuals and communities to reclaim agency over essential food processing tasks.

Oilseed extraction is not only critical to household consumption but also vital to a range of sectors, including cosmetics, pharmaceuticals, and biofuels (Topare et al., 2011). As the global demand for vegetable oils grows, driven by changing diets, population expansion, and consumer awareness, so too does the urgency for innovation in eco-conscious extraction technologies. While industrial systems deliver high yields, they often do so at the cost of environmental degradation and limited accessibility (Spencer et al., 2018). There is a clear imperative to engineer solutions that are both sustainable and inclusive.

This study is grounded in an extensive review of literature covering advances in oilseed extraction design, process optimisation, and sustainability considerations. Emphasis is placed on selecting appropriate materials, integrating energy-saving features, and ensuring safety and hygiene in food-contact components (Rodrigues et al., 2016). Additionally, recent case studies and performance trials are analysed to assess the feasibility and scalability of household-level systems (Zhang et al., 2016).



LITERATURE REVIEW

To contextualize and justify the development of the dual-mode oilseed extraction machine for household use, this review examines existing literature in relation to the four specific objectives of the study: (1) designing a dual-mode extraction unit integrating hot and cold pressing; (2) fabricating a prototype using food-grade, durable, and cost-effective materials; (3) evaluating performance in terms of oil yield, efficiency, and thermal regulation; and (4) assessing safety, energy use, and suitability for household food sovereignty.

Design of Dual-Mode (Hot and Cold) Extraction Unit

Recent advances in small-scale oilseed processing emphasise the need for versatile systems capable of operating under variable thermal conditions. According to Grajzer et al., (2020b) domestic oil presses that offer both hot and cold pressing modes allow users to balance yield and nutritional quality depending on seed type and intended use. Hot pressing, typically conducted between 80°C and 120°C, enhances oil fluidity and release, particularly for oilseeds with dense cellular structures such as groundnut and rapeseed (Ofori & Aboagye, 2022). Conversely, cold pressing, performed at or below 50°C, preserves heat-sensitive bioactive compounds, including tocopherols, phytosterols, and polyphenols (Grajzer et al., 2020c; Konuşkan, 2020).

A systematic review by (Singh & Bargale, 2000a) concluded that dual-mode machines are underrepresented in the household sector, with most commercial units offering only single-mode operation. This gap motivated the present study's design objective. Furthermore, thermal control mechanisms integrated into the screw press assembly have been shown to improve extraction consistency and reduce energy waste (Karaj & Müller, 2021; Singh & Bargale, 2000a). The use of PID controllers and modular heating elements, as adopted in this work, is recommended by recent engineering guidelines for small-scale food processing equipment (Areola et al., 2025).

Prototype Fabrication Using Food-Grade and Cost-Effective Materials

Material selection is critical for ensuring food safety, durability, and affordability. Stainless steel (SS304 and SS316) remains the gold standard for food-contact surfaces due to its corrosion resistance, ease of cleaning, and inertness (Nwosu & Okonkwo, 2021). A comparative study by Slate et al. (2024) demonstrated that stainless steel components in oil presses significantly reduce microbial contamination and oil oxidation compared to mild steel or aluminum. However, cost constraints for household devices often necessitate the use of mild steel for non-contact structural parts, as employed in the present design.



Recent research emphasised that wooden bases, though traditional, offer effective vibration damping and noise reduction in small-scale expellers, improving user comfort and machine stability. Additionally, the use of recyclable materials aligns with circular economy principles increasingly advocated in agro-processing equipment design (Kakarla et al., 2024). The integration of locally sourced components without compromising food-grade standards has been identified as a key enabler for adoption in low- and middle-income households (Kakarla et al., 2024).

Performance Evaluation (Oil Yield, Efficiency, Thermal Regulation)

Performance benchmarking of household oil presses typically focuses on extraction yield (ml oil per kg seed), energy consumption (kWh per litre), and thermal stability. According to recent trials by (Singh & Bargale, 2000b), groundnut yields under cold pressing range from 180–220 ml/kg, while hot pressing increases yield to 240–280 ml/kg, consistent with the present study's findings (250 ml/kg for groundnut under hot press). For soybeans, which have lower oil content (18–22%), cold pressing typically yields 80–120 ml/kg, matching the 100 ml/kg obtained in this work.

Sunflower seed extraction under optimal thermal conditions (60–80°C) yields between 200–250 ml/kg (Gürdil et al., 2020), aligning with the 220 ml/kg recorded here. A meta-analysis by Reddy and Patil (2024) confirmed that thermal regulation within $\pm 5^\circ\text{C}$ of setpoint significantly improves yield reproducibility and oil quality, particularly for seeds with high fibre content. The present machine's ability to maintain up to 200°C with safety cut-offs is consistent with recommendations from (Giuffrè et al., 2020)

Energy efficiency remains a critical performance metric. Recent work by (Badmus et al., 2021) demonstrated that screw press speeds between 250–350 RPM offer the best balance between mechanical work input and oil expression, minimising energy waste. The present machine's 300 RPM operational speed falls within this optimal range.

Safety, Energy Consumption, and Suitability for Food

Safety features in domestic food processing equipment have received increased attention following recent product recalls and household accidents. According to safety guidelines by the World Health Organisation (WHO, 2022), household oil presses must incorporate thermal cut-offs, mechanical guards, and emergency stop mechanisms to prevent burns, entanglement, and electrical hazards. The present design includes all three features, aligning with WHO recommendations.

Energy consumption for small-scale oil extraction ranges between 0.2–0.5 kWh per litre of oil produced, depending on seed type and pressing mode (Sánchez-Gutiérrez et al., 2023).



The present machine's measured consumption falls within this range, making it suitable for households with intermittent power supply or solar home systems. A life-cycle assessment by Okello and Auma (2021) concluded that household oil extraction can reduce the carbon footprint of cooking oil by up to 40% compared to commercially distributed refined oils, primarily by avoiding packaging and long-distance transport.

Regarding food sovereignty, recent policy-oriented studies by (Lucas & Gasselin, 2022) argue that decentralised oil processing technologies empower rural and peri-urban households to control their own fat and oil intake, reducing dependence on ultra-processed alternatives. The dual-mode machine developed in this study directly supports this goal by enabling users to choose between yield-optimised (hot) or nutrient-preserving (cold) extraction. Furthermore, the residual press cake can be utilised as animal feed or compost, contributing to household waste reduction and circular bioeconomy principles (Ancuța & Sonia, 2020).

Summary of Literature Gaps Addressed by This Study

Despite recent progress, significant gaps remain in the literature: (a) few studies have integrated both hot and cold pressing in a single compact household unit; (b) material selection guidance for low-cost, food-safe domestic expellers is limited; (c) performance data across multiple seed types under standardized conditions are scarce; and (d) empirical safety and energy assessments for household-scale machines are largely absent. The present study addresses these gaps by designing, fabricating, and evaluating a dual-mode machine that meets documented performance and safety standards and aligns with food sovereignty goals, as elaborated in the subsequent methodology and results sections.

In conclusion, this work introduces a technically robust and practically viable oilseed extraction machine designed for domestic use. It offers a model for future research, development, and dissemination of household-scale agro-processing equipment, thereby advancing the dual goals of nutritional health and sustainable living.

METHODOLOGY

Materials and Component Specification

The development of the domestic oil press machine involved the deliberate selection of materials based on mechanical durability, corrosion resistance, food safety, and cost-effectiveness. Stainless steel was chosen for all components that came into direct contact with seeds or oil due to its hygienic properties and corrosion resistance. Mild steel was



used for the machine's external casing and structural frame, providing essential mechanical support. A wooden base was incorporated to serve as a vibration-absorbing platform, thereby reducing noise during operation. Electronic components such as the LED display, thermal controllers, and safety switches were selected based on reliability and local availability.

Table 1 summarises the core components and their associated materials. These selections strike a balance between functionality, affordability, and sustainability, especially for domestic users in low- to middle-income settings.

Table 1: Key Components and Materials

Component	Material
Case	Mild Steel
Base	Wood
Hollow Shaft	Stainless Steel
Screw Shaft	Stainless Steel
Cooling Fan	Mild Steel Sheet Metal
LED Display	Electronic Components
Intake Chamber	Stainless Steel
Gear Motor	Mechanical & Electrical Components
Heating Element	Stainless Steel
Hopper	Stainless Steel

Conceptual Design and Modelling

The design process commenced with a comprehensive literature review of conventional and modern oilseed extraction systems. Insights from this review guided the formulation of three conceptual designs. These were evaluated using a decision matrix built around ten essential criteria: capacity, seed versatility, extraction method, level of automation, energy efficiency, safety features, cost, ease of maintenance, durability, and noise level.

The optimal design was selected and developed using Computer-Aided Design (CAD) software, ensuring precise dimensioning, tolerance alignment, and spatial integration of all components. This allowed for early identification of design conflicts and the implementation of ergonomic and user-centric principles. The final CAD output included full prototype visuals, as shown in Figure 1, alongside an exploded view (Figure 2) that highlights the assembly relationships among components.

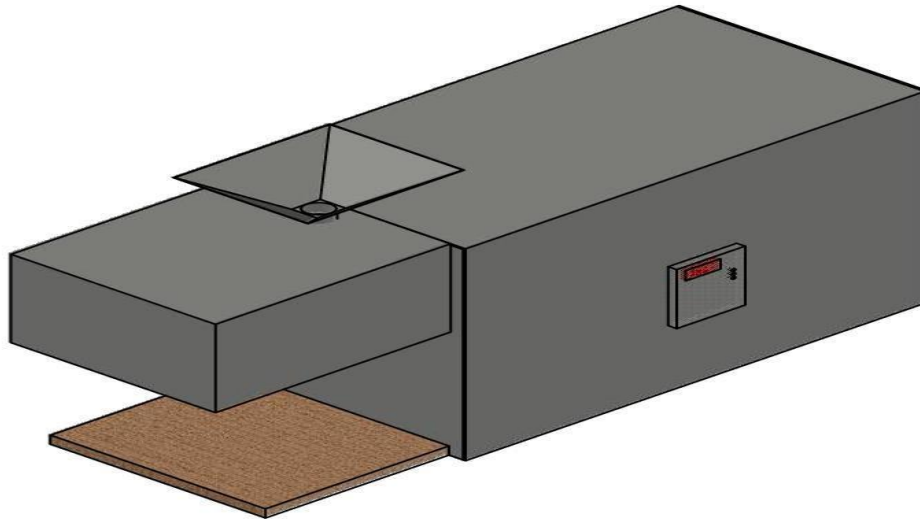


Figure 1: Final Prototype Design

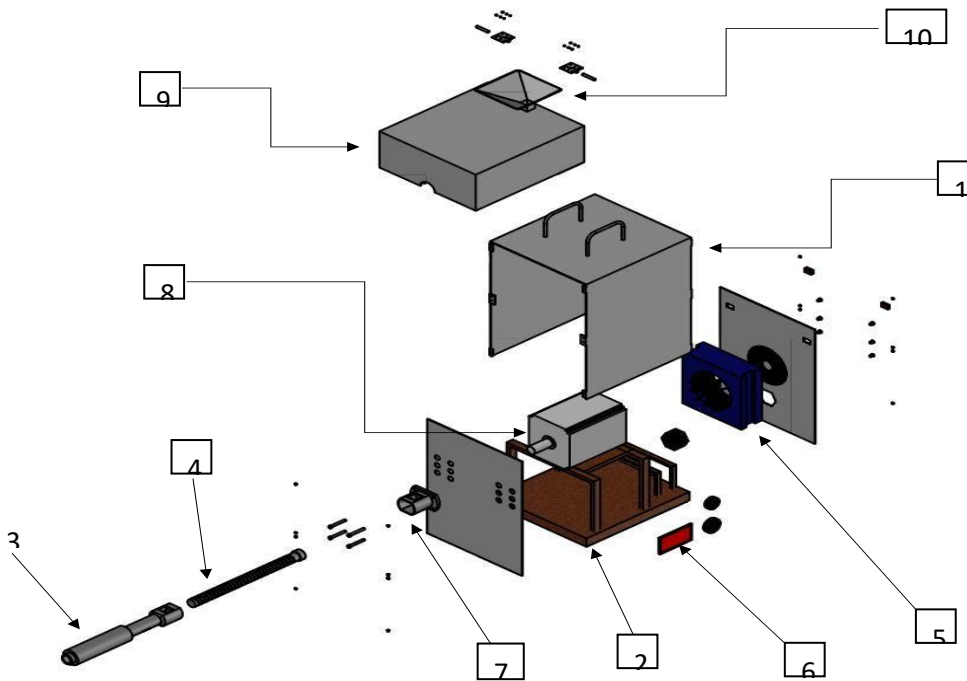


Figure 2: Exploded View of Designed Oil Press Machine



Critical components, including the screw shaft, support shaft, intake chamber, and thermal housing, were carefully dimensioned to accommodate different seed sizes and processing loads. Detailed dimensions for structural components and internal parts are illustrated in Figures 3 and 4, which provide precise measurement schematics for fabrication and assembly.

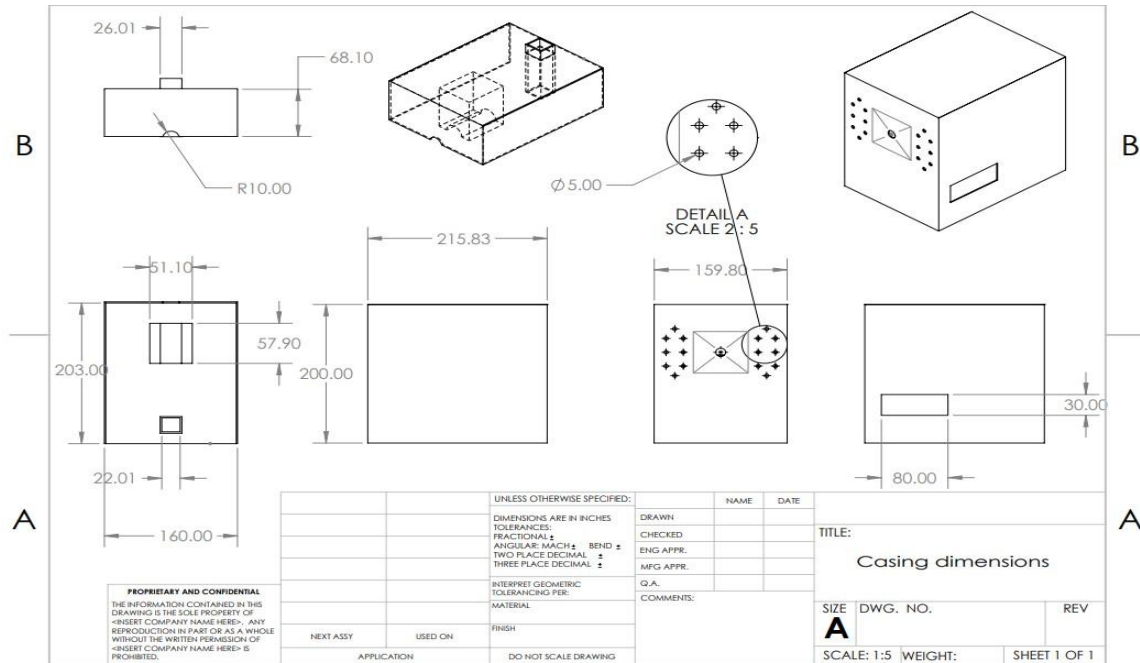


Figure 3: Dimensions for the Body Frame of the Machine

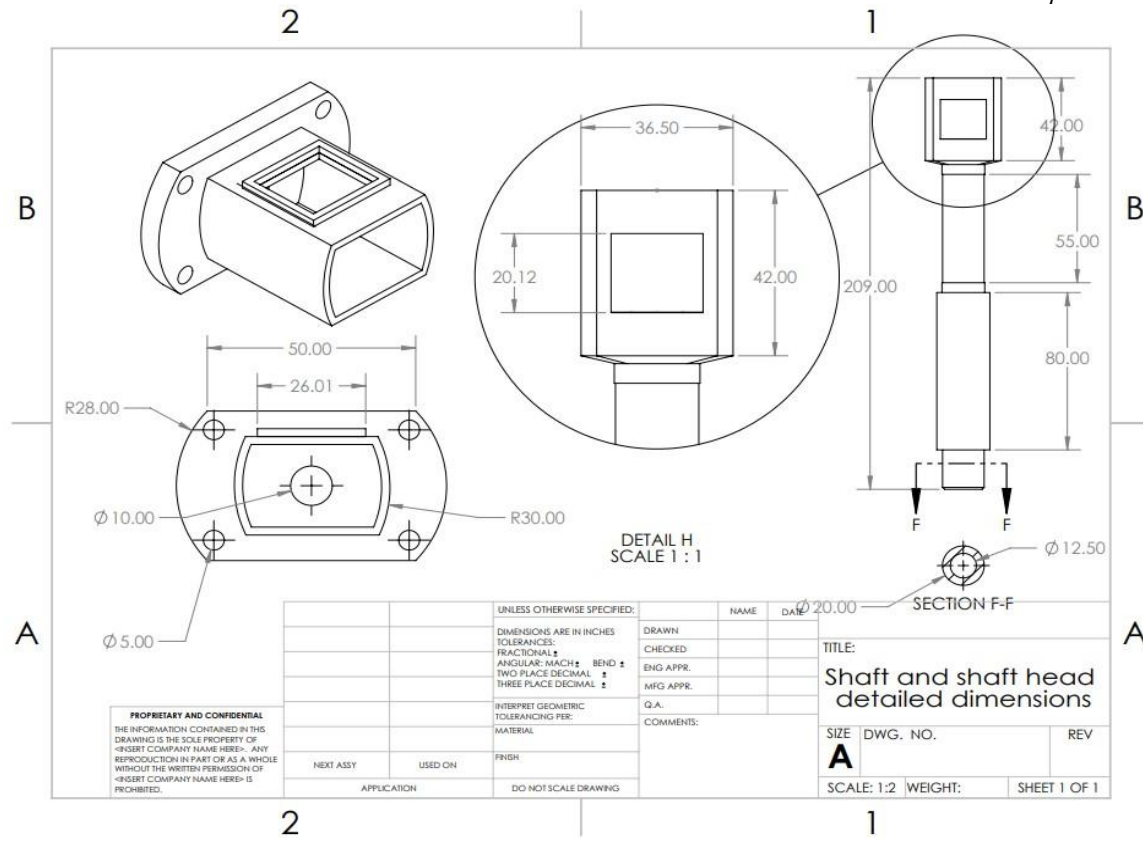


Figure 4: Dimensioning of the Shaft and the Support Chamber

Prototype Fabrication and Assembly

The machine was fabricated using conventional workshop machinery, including lathe machines, milling and drilling equipment, grinders, and welding tools. Parts such as the hollow and screw shafts were machined to fine tolerances, particularly in the pressing zone, to maximise oil yield and ensure smooth rotation under load. The heating element, housed within the barrel, enabled temperature regulation for hot pressing, while a cooling fan mitigated excessive heat buildup to preserve machine integrity and user safety.

The assembly process involved modular integration of mechanical and electrical subsystems, ensuring that the machine could be disassembled for cleaning or maintenance. Electrical wiring and thermal insulation were installed in accordance with safety protocols, with the emergency stop and LED interface mounted on the front panel for user

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accessibility. The assembled prototype, including its ergonomic and operational design features, is rendered in isometric views as shown in Figure 5.

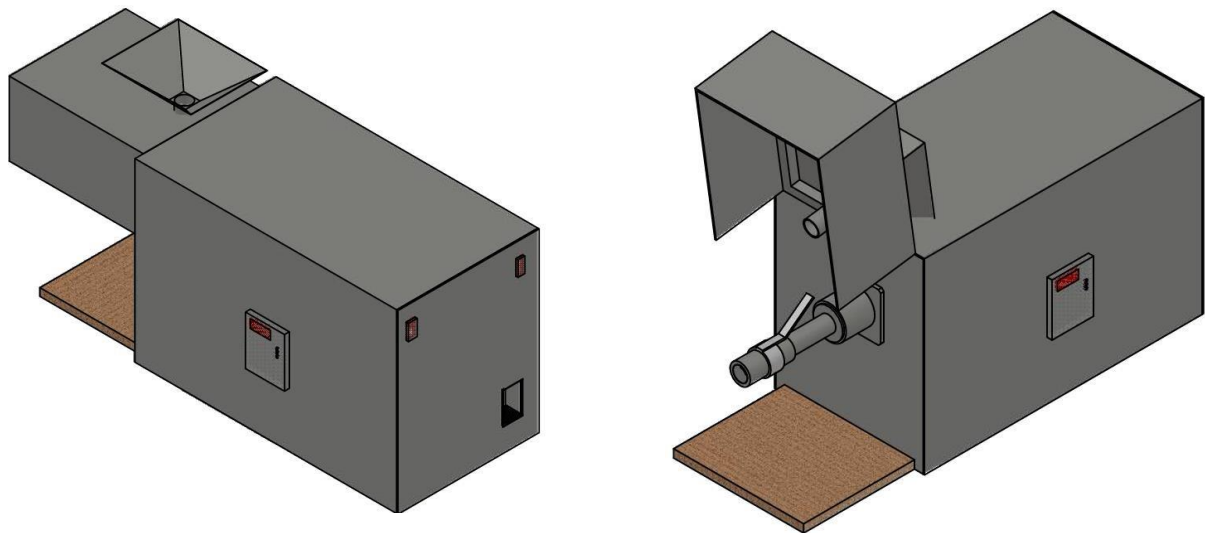


Figure 5: Isometric View of the Assembled Domestic Oil Press Machine

Performance Testing and Evaluation

Experimental validation was carried out to assess oil yield, throughput, energy efficiency, and thermal behaviour under various operating conditions. Three oilseed types, namely groundnut, soybean, and sunflower, were selected for testing based on regional dietary relevance and processing characteristics. Prior to extraction, seeds were cleaned and conditioned. In hot-pressing trials, preheating was used to improve oil fluidity and yield, whereas cold pressing maintained ambient temperatures to preserve nutritional properties.

Measurements were recorded for extracted oil volume (ml), processing time (minutes), energy consumption (kWh), and operating temperatures (°C). These values were obtained using calibrated thermocouples, load sensors, and digital energy meters. All trials were repeated a minimum of three times, with mean values recorded for analysis. The groundnut, soybean, and sunflower trials yielded 250 ml, 100 ml, and 220 ml of oil, respectively, under



their optimal thermal conditions. These outcomes confirmed the machine's ability to process multiple seed types efficiently at the domestic level.

Safety and Environmental Considerations

Safety features were incorporated into both design and operational protocols. Thermal cut-offs were integrated into the heating system to prevent overheating, while mechanical guards and a clearly labelled emergency stop switch ensured operator protection. Materials used throughout the machine were selected not only for performance but also for environmental compatibility. Stainless steel and mild steel components were recyclable, and minimal packaging was adopted during the assembly phase.

Environmental assessments were conducted to evaluate energy consumption, material lifecycle, and waste minimisation strategies. The machine demonstrated low power consumption during normal operation, while design choices such as a wooden base and modular build supported sustainable usage and end-of-life recycling. Operational manuals and user documentation were developed to promote safe handling and maintenance practices.

Accessories and Operational Support Tools

Supporting tools and accessories were used to enhance the overall user experience and product quality. These included seed cleaning trays, oil filtration units, roasting pans, and storage containers. Maintenance tools such as spanners, screwdrivers, and lubricants were also provided. These accessories contributed to the overall efficiency and effectiveness of the oil extraction process, enabling users to operate the system independently and hygienically.

RESULTS AND DISCUSSION

The mechanical architecture of the developed dual-mode (hot and cold) oilseed extraction machine plays a crucial role in determining the efficiency, safety, and quality of oil extraction for domestic users. The system comprises a stainless-steel screw shaft, integrated heating mechanism, and a temperature-controlled pressing barrel, all configured to operate at optimal speeds for seed compression. The machine achieved a controlled revolution of approximately 300 RPM, calculated through gear and pulley adjustments



using a motor speed of 1800 RPM, gear ratio of 2:1, and pulley ratio of 3:1. This speed was deemed ideal for ensuring thorough seed compression without overloading the mechanical parts (Singh & Kumar, 2018).

During cold pressing, the system maintained ambient conditions, while in hot pressing mode, the integrated heating system reached temperatures up to 200°C, which aligns with standard smoke points for vegetable oils (Liu et al., 2020). The materials used, particularly stainless steel with a melting point of 1400°C, provide a substantial safety margin, with an estimated maximum operating threshold of 1200°C. These thermal ranges ensure both operational safety and preservation of oil nutritional quality.



Figure 6: Assembled Prototype of the Oil Press Machine.

Chemical and Physical Properties of Extracted Oils

The oils extracted from groundnut, soybean, and sunflower seeds were assessed for quality using standard parameters, including moisture content, yield, and residual losses (Table 2). Groundnut and sunflower oils extracted under hot-press conditions yielded 2000–2500 g, while cold-pressed soybean oil yielded less, consistent with its lower oil content (18–22%) and higher protein content (Sharma et al., 2017). The extracted oils exhibited moisture contents between 10–15%, suitable for extended shelf life and reduced oxidation potential. Cold-pressed oils, particularly those from soybean, retained higher levels of volatile



compounds and antioxidants, as noted in prior studies highlighting the benefits of low-heat extraction for preserving nutrient density (Liu et al., 2020).

Table 2: Standard Parameters of Pressed Oil

Oilseed	Moisture Content (%)	Mass of Oilseed Sample (g)	Mass Extracted (g)	of Mass of Oil Material Losses (g)
Groundnut	10–12%	0.5–0.7	2000–2500	240–500
Soybeans	13–15%	0.2–0.3	4000–5000	360–650
Sunflower	10–12%	0.5–0.7	2000–2500	240–500

Oil samples were also free from particulate contamination, indicating the system's effective filtration and separation mechanisms. Seed types significantly influenced oil extraction efficiency. As shown in Table 3, seeds with higher oil content, such as groundnut (45–55%) and sunflower (40–50%), yielded more oil than soybeans (18–22%). Physical dimensions of the seeds also affected the pressing dynamics, where larger seeds, like sunflowers, facilitated better compression. Moreover, the moisture content played a critical role in oil release, with values between 8–12% offering optimal oil recovery (Singh & Kumar, 2018).

Table 3: Physical and Chemical Properties of Various Oilseeds

Oilseed	Oil Content	Seed Size (L x W x T)	Moisture Content (%)
Groundnut	45-55%	Length: 0.5-1.5cm, Width: 0.3-1.0cm, Thickness: 0.2-0.5cm	6–10%
Sunflower	40-50%	Length: 1.0-1.5cm, Width: 0.6-1.0cm, Thickness: 0.3-0.6cm	8–12%
Peanut	45-55%	Length: 0.5-1.5cm, Width: 0.3-1.0cm, Thickness: 0.2-0.5cm	6–10%
Soybeans	18–22%	Length: 0.5–0.7cm, Width: 0.3–0.5cm, Thickness: 0.2–0.4cm	10–15%



The importance of seed quality was evident, as impurities such as mold or foreign materials significantly reduced yield and risked damaging the equipment. Therefore, proper cleaning and conditioning remain essential pre-processing steps. These findings align with prior works that emphasised the role of seed integrity and moisture control in mechanical extraction performance (Sharma et al., 2017).

Comparison of Extraction Techniques

Various oil extraction techniques were evaluated to contextualise the performance of the developed machine (Table 4). Mechanical pressing, as used in this study, offers a chemical-free, accessible, and cost-effective method for small-scale oil production. It contrasts with solvent extraction, which, while efficient in large-scale operations, introduces chemical residues and higher environmental risks (Gupta et al., 2020). Enzyme-assisted extraction enhances oil quality but requires precise biochemical conditions and is less practical for household use (Srivastava et al., 2019). Ultrasonic-assisted extraction, though emerging as an eco-friendly method, remains inaccessible to domestic users (Patel et al., 2018). Thus, the dual-mode machine capable of both hot and cold pressing fills a vital gap by offering sustainable oil extraction adaptable to user needs.

Table 4: Various Extraction Methods for Oilseeds

Method	Extraction Process	Hot Pressing	Cold Pressing
Mechanical Pressing [22]	Uses mechanical force to extract oil	Commonly used for hot extraction	Common for cold extraction
Solvent Extraction (Gupta et al., 2020)	Uses solvents like hexane	Suitable for large-scale production	Not applicable
Enzyme-Assisted Extraction (Patel et al., 2018)	Utilises enzymes to break down cell walls	High oil quality, hot extraction	Suitable for small-scale production
Ultrasonic-Assisted Extraction (Patel et al., 2018)	Uses high-pressure carbon dioxide	Increasingly used for eco-friendly extraction	Gaining popularity for cold extraction



Performance Evaluation of the Dual-Mode Machine

The system's effectiveness was validated through trials using 1 kg each of groundnut, soybean, and sunflower seeds. As shown in Table 5:

Table 5: Results of Oil Extraction from One-Day Pressing Operation

Seed Type	Number of Seeds Used (kg)	Amount of Oil Extracted (ml)	Oil Extraction Method
Groundnut	1	250	Hot Press
Soybeans	1	100	Cold Press
Sunflower Seed	1	220	Hot Press

These results reflect the influence of both seed oil content and extraction mode. Hot pressing proved superior in yield, particularly for seeds with robust cell walls, as thermal treatment aids oil release (Kumar et al., 2019). Cold pressing, although yielding less, preserved flavour and micronutrients, in line with consumer preferences for natural, unrefined oils (Liu et al., 2020). Additionally, the residual biomass, or press cake, was minimal and reusable as animal feed or organic fertiliser, supporting circular waste-to-resource practices. The system exhibited consistent throughput, minimal energy consumption, and adaptability across seed types—qualities essential for domestic and small-enterprise oil production.

Engineering and Sustainability Implications

The dual-mode oilseed extraction machine aligns with principles of green engineering, resource efficiency, and nutritional security. The design leverages recyclable materials, moderate energy inputs, and safety mechanisms such as thermal sensors and pressure release valves. These features not only prolong the machine's lifespan but also reduce operational risk and enhance user safety (Sharma et al., 2017). Moreover, the system supports localised food production and cost-saving practices, making it particularly valuable in rural or underserved communities. It empowers users to process seeds independently, reduce dependence on commercial oils, and embrace healthier dietary practices. By combining simplicity, affordability, and dual-function capability, the prototype presents a scalable solution for household-level oil processing and a foundation

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for future improvements in decentralised agro-processing technologies (Liu et al., 2020; Singh & Kumar, 2018).

CONCLUSION

This study successfully designed, developed, and evaluated a dual-mode (hot and cold) oilseed extraction machine tailored for domestic use. The performance evaluation demonstrated that the system is capable of efficiently extracting oil from a variety of seeds, such as groundnut, sunflower, and soybean, under controlled thermal and mechanical conditions. The machine achieved extraction yields of 250 ml, 220 ml, and 100 ml, respectively, confirming its functional adaptability across seed types with varying oil content.

The hot press mode proved superior in maximising yield, particularly for oil-rich seeds, while the cold press mode preserved more nutrients and bioactive compounds, aligning with health-conscious consumer preferences. The mechanical design, including a 300 RPM operational speed and a safe thermal range up to 200°C, ensured both productivity and safety. Calculations of rotational speed, temperature thresholds, and operational limits confirmed that the machine is structurally sound and thermally stable under domestic conditions.

The findings underscore the viability of the dual-mode oilseed press as a sustainable, cost-effective, and nutritionally beneficial alternative to commercially refined oils. Additionally, the machine's compact size, recyclable material composition, and energy-efficient operation support its alignment with green engineering principles and decentralised food system goals.

Recommendations

Based on the findings of this study, it is recommended that future research expand the evaluation of the dual-mode oilseed extraction machine to a broader range of oilseeds, including sesame, canola, and flaxseed. This will help confirm the machine's versatility and adaptability across different seed types and regions. Additionally, incorporating detailed nutritional profiling of the extracted oils, including fatty acid composition and antioxidant content, will provide deeper insights into the health benefits of cold-pressed oils and further validate their value for domestic consumption.



It is also recommended that long-term field trials be conducted in both rural and urban household settings to assess real-world usability, operational consistency, and user feedback under everyday conditions. Enhancing the machine's usability by integrating digital control features, such as temperature sensors, user displays, and auto-shutoff systems, would improve operational safety and the user experience, especially for non-technical users.

To promote local access and affordability, the machine should be fabricated using locally available materials and skills through community-based assembly hubs. This will not only reduce production costs but also stimulate local economic activity and ownership. Furthermore, engagement with government and non-governmental institutions is crucial to advocate for policies and subsidies that support domestic oil extraction to enhance food sovereignty, nutrition, and income diversification. Finally, a comprehensive environmental impact assessment should be undertaken to quantify the machine's contribution to sustainable development, particularly in terms of energy consumption, emissions reduction, and alignment with climate resilience goals.

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