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Design and Manufacturing of Pedal Operated Sesame Oil Extraction Machine

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Abstract

Sesame seed oil is essential edible oil in Ethiopia, but small-scale extraction is constrained by inefficient manual and animal-powered methods or expensive motorized machines that require electricity. This study aims to design, fabricate, and evaluate a pedal operated sesame oil extraction machine (POSOEM) suitable for rural and semi-urban communities. The research followed a structured methodology including customer needs identification, conceptual and detailed design, component analysis using ANSYS stress simulation, and prototype manufacturing. Experimental testing was carried out using Taguchi's L8 orthogonal array with three control parameters: particle size (1.0, 1.5 mm), roasting time (10, 15 min), and moisture content (8%, 10%). Results showed that the machine achieved a maximum oil yield of 68.05% and an extraction efficiency of 34.03% at the optimum condition of 15 min roasting time, 1.0 mm particle size, and 10% moisture content. The overall average performance was an oil yield of 62%, a capacity of 19.25 kg/hr, an extraction rate of 7.74 l/hr, and an extraction efficiency of 31%. The prototype production cost was approximately 90,000 Birr, making it affordable for small-scale processors. Compared to existing methods, the POSOEM demonstrated higher throughput, low energy requirements, and additional social benefits such as encouraging physical exercise. The study concludes that a pedal operated solution provides an affordable, sustainable, and energy-independent alternative for smallholder farmers and local processors. Future work should focus on improving material selection, optimizing seed flow, and exploring renewable energy integration such as solar-assisted operation.

Keywords: *oil extraction, pedal operated machine, prototype design, taguchi method, sesame oil, rural technology*

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1. Introduction

Sesame (*Sesamum indicum L.*), is renowned as the "queen of oilseeds," is a critical cash crop and a primary source of high-quality edible oil in Ethiopia (Murwan et al. 2008). The country ranks among the world's top sesame producers, with the 'Whitish Humera' variety being particularly prized for its superior oil content (44-58%) and organoleptic properties (Murwan et al., 2008). The seeds are small, flat, and oval, with an average length, width, and thickness of 3.2 mm, 1.9 mm, and 1.0 mm, respectively. Mechanical expression requires an applied pressure in the range of 25-50 MPa, depending on seed conditioning (Elkhaleefa & Shigidi, 2015; Ibrahim, & Onwualu, 2005). Paradoxically, despite this potential, Ethiopia imports approximately 80% of its domestic edible oil consumption, revealing a stark deficit in local processing capacity (High Quest Partners, 2011; ACP-EU, 2017).

This deficit is perpetuated by the reliance on rudimentary extraction technologies. The two predominant methods, manual screw press and the camel-drawn rotary mortar (known as ghani)—are characterized by low throughput (3.8-5 kg/hr), high labor input, and inconsistent oil yield (25-35% efficiency) (Alemu & Meijerink, 2010, Elkhaleefa & Shigidi, 2015). Modern motorized screw presses, often imported from countries like China, offer higher capacities but their high initial cost, dependence on unreliable electricity, and complex maintenance render them inaccessible to the vast majority of smallholder farmers and rural entrepreneurs (Ferchau, 2005). This technological gap stifles local economic development and perpetuates post-harvest losses.

The development of intermediate technology offers a promising pathway to address this challenge. Pedal power, which leverages the strong leg muscles of a human operator, can generate significantly more sustained power (≈75 W) than arm cranking and is well-suited for applications requiring continuous operation. An average adult can maintai

n this power output for 60-90 minutes before requiring a short rest, making it a reliable energy source for batch processing (Anyanwu, 2016). This paper details the engineering development of a Pedal-Powered Sesame Oil Extraction Machine (POSOEM), with the overarching goal of creating a robust, cost-effective, and efficient machine that empowers rural communities to add value to their agricultural produce.

Figure 1

Conventional Sesame Oil Extraction Methods in Ethiopia

Note. Camel-powered rotary mortar, Aksum exhibition (a), Manual screw press. Aksum City local extractor (b), and Small Oil Mill imported from China (c)

1.1. Global Context of Small-Scale Oil Extraction

The challenge of efficient, small-scale oil extraction is not unique to Ethiopia but is a common issue in many developing regions. Research into appropriate technologies for agro-processing has been ongoing for decades, with a focus on bridging the gap between traditional methods and industrial-scale systems. Mechanical extractor methods, particularly screw presses, have been identified as the most suitable technology for small to medium-scale operations due to their continuous operation, relatively high efficiency, and lower capital cost compared to solvent extraction systems (Ward, et al., 1995). The superiority of screw presses over hydraulic presses for continuous flow operations has been established in previous studies, making them a preferred basis for new designs [Singh, 2008).

1.2. Previous Work on Mechanical Extraction Design

Significant research has been conducted to optimize the design and performance of mechanical extractors. Singh et al. [10] addressed common issues of choking and jamming by designing a double-stage tapered screw press, which reduced the required pressure for 80% oil recovery and minimized energy losses. This work highlights the importance of screw geometry in extractor performance. Further innovation was demonstrated by (Isobe Ethiopia Al., 2002), who developed a twin-screw press achieving over 93% oil recovery from sunflower seeds, indicating the potential for high efficiency with optimized screw configuration.

The drive for sustainability has also led to the exploration of alternative energy sources. Mpagalile and Hannah (2012) successfully developed a solar-powered bridge-type screw press, proving the feasibility of renewable energy for oil extraction. However, the high cost of photovoltaic systems and energy storage remains a barrier to widespread adoption in rural settings. Studies like that of (Olaniyan et Al., 2012) on a screw press for palm kernel and soybean emphasized designs that are simple enough for local fabrication and repair, a principle that is central to the design philosophy of the current study.

1.3. Sesame Oil Extraction Research

Research specific to sesame oil has focused largely on pre-treatment and conditioning parameters to maximize yield. (Elkhaleefa & Shigidi, 2015] determined that solvent extraction with n-hexane was optimized with a seed particle size of 0.8-1 mm, a finding that informs the particle size parameters tested in this study. (Kamel-Eldin et al., 1992) documented the traditional camel-powered ghani process, noting that oil release began after 30 minutes at a temperature of 41°C, illustrating the time-consuming nature of traditional methods. (Warra, 2011) reported a 41% efficiency for a method involving heating, shaking, and water addition, which is comparable to the lower end of efficiencies achieved by existing local methods in Ethiopia.

1.4. The Ethiopian Context and Local Technologies

In Ethiopia, the sesame sector is of paramount importance to the national economy, yet the technology for local value addition remains underdeveloped. As noted by Alemu and Meijerink (2010) a significant portion of Ethiopian sesame is exported as raw seed, forgoing the economic benefits of domestic processing. The existing local technologies—the manual screw and the camel-drag mortar—have been documented to have multi-dimensional problems, including low production capacity, high labor requirement, and, in the case of the camel-drag, large spatial footprint and short component lifespan.

Motorized mills imported from countries like China are available but are often ill-suited to the rural context due to their dependence on unreliable electricity, high initial cost, and difficulty in maintenance and repair for local technicians (Ferchau, 2005). This creates a persistent technological gap that hinders the productivity and profitability of small-scale processors and farmers.

1.5. Research Gap

A comprehensive review of the literature reveals a clear research gap. While considerable work has been done on optimizing screw press design for large-scale or motorized operations, studying the parameters affecting sesame oil yield, and developing solar-powered systems, there is a distinct lack of focused research on designing and optimizing a dedicated, human-powered (pedal-operated) mechanical extractor for small-scale sesame processing. Previous studies on human-powered devices are often generic, and studies on sesame extraction often focus on chemical methods or pre-treatment, not on the development of an integrated, appropriate technology.

Therefore, this research aims to fill this gap by systematically: 1) Designing a pedal-operated sesame oil extractor (POSOEM) based on engineering principles and user-centered design. 2) Fabricating a prototype using locally available materials and skills. 3) Empirically evaluating the performance of the prototype and the effect of key operational parameters (roasting time, particle size, moisture content).

2. Materials and Methods

2.1. Concept Generation and Concept Selection

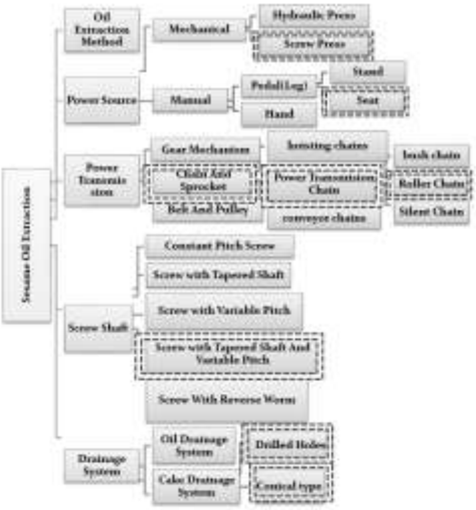
The design process adhered to a structured product development methodology (Ulrich & Eppinger, 2015), beginning with a comprehensive assessment of user needs in Tigray. The primary design drivers were identified and translated into quantitative design specifications:

1. Capacity: ≥ 15 kg/hr.
2. Oil Yield: > 50%.
3. Power Source: Human pedaling, independent of electricity.
4. Screw Shaft Speed: ~150 rpm.
5. Required Pressure: Designed to generate > 30 MPa for effective oil expression.
6. Cost: Target < 90,000 ETB.

The conceptual designs were developed following the optimization flow process is illustrated as follows.

Figure 2

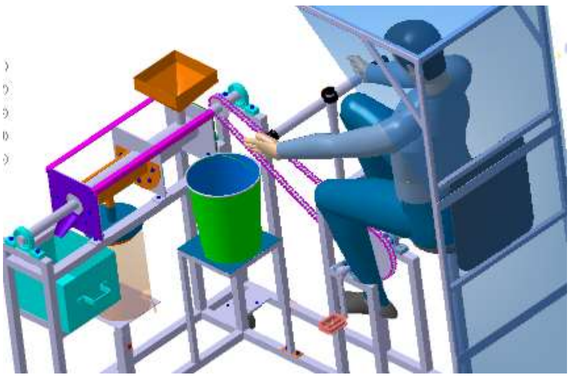
POSOEM Conceptual Design Optimization Flow Process



Accordingly, to the design optimization (**Figure 2**), four concepts was generated, and from generated concepts, a pedal-operated, chain-driven screw press (Fig. 3) was selected through a weighted decision matrix. This concept excelled in criteria such as operational cost (energy cost), production capacity, and potential for local manufacturability.

Figure 3

Selected Design Concept for the Pedal-Powered Sesame Oil Extraction (POSOE)



2.2. Final Design and Component Selection

The final design was decomposed into five subsystems: Drive, Main, Drainage, Skeleton, and Fasteners. Pedal crank drives the screw shaft with the help of chain drive to transmit power from pedal to screw shaft. The material to be pressed is fed through hopper and moves between screw and barrel; then propelled by the rotating screw shaft in the direction parallel to the axis. The seeds are fed at where the thread depth of screw is maximum. When Screw shaft rotates inside the barrel, there is a small clearance between the barrel and the screw shaft. This small clearance is used for avoiding the seeds penetrating between the outside diameter of the screw shaft and the inside surface of the barrel. Then after the material is progressively compressed, it moves on towards the discharge.

2.3. Engineering Analysis

A bottom-up engineering analysis was conducted to ensure the structural integrity of the machine under operational loads.

2.4. Power and Torque Calculation:

Based on literature for mechanical oil expression (Aremu & Ogunlade, 2016; Ibrahim & Onwualu, 2005), the specific energy required for pressing sesame seeds is approximately 60-100 kJ/kg. Targeting a capacity of 19.25 kg/hr, the required power was calculated as Equ(1):

$$P_{required} = \frac{(Specific\ Energy \ * \ Capacity)}{Time} \qquad 1.1$$

$$= \frac{\left(80\,\frac{kJ}{kg} * \ 19.25\ kg\right)}{3600\ s} \approx \ 428\ W$$

Accounting for transmission losses (≈20% in chain drive and bearings), the input power required from the operator is calculated using Equ(2):

$$P_{input} = \frac{P_{required}}{efficiency} \quad 1.2$$

$$= \frac{428\,W}{0.80} = 535\,W$$

This exceeds the sustained human power output of 75 W, indicating that the actual pressing process is intermittent or that the specific energy in this configuration is lower. For a more conservative and ergonomic design, the analysis proceeded with the sustainable human power of 75 W. The torque on the screw shaft rotating at 150 RPM was calculated as Equ (3):

$$Torque\ (\tau) = \frac{P * 60}{2 * \pi * N} \quad 1.3$$

$$= (75\,W * 60) / (2 * \pi * 150\,RPM) = 4.77\,Nm$$

This torque, while low, is used for the initial component design. The actual forces during pressing will be higher, and the design was checked for a maximum conceivable torque of 45 Nm, as estimated from the material strength.

2.5. Component Stress Analysis:

The screw shaft was analyzed for combined shear stress from torsion and crushing stress. The torsional shear stress (τ = T * r / J) was calculated for the root diameter of the screw. For a maximum torque of 45 Nm, the shear stress was found to be 35 MPa. The von Mises stress was estimated to be well below the yield strength of AISI 1045 steel (530 MPa). The FEA (**Figure 4a**) later confirmed a maximum stress of 71 MPa, providing a high safety factor.

The pedals crank shaft is subject to pure torsion from the pedaling force. Assuming a maximum human force of 600 N applied to a 170 mm long pedal crank, the input torque is calculated using Equ(4):

$$T_{pedal} = Force * Crank\ Length \quad 1.4$$

$$= 600\,N * 0.17\,m = 102\,Nm$$

The shear stress (τ) on the 20 mm diameter crank shaft (made of AISI 1018 steel, Sy = 370 MPa) was calculated using Equ(5):

$$J = \pi * d^4 / 32 = \pi * (0.02)^4 / 32 = 1.57\,x\,10^{-8}\,m^4$$

$$\tau_{max} = \frac{(T * r)}{J} \quad 1.5$$

$$= \frac{(102\,Nm * 0.01\,m)}{1.57\,x\,10^{-8} m^4} = 65\,MPa$$

The factor of safety is N = Ssy / τ_max = (0.58 * 370 MPa) / 65 MPa ≈ 3.3, which is acceptable.

In the selection of Chain Drive, the roller chain (ANSI #40) was verified based on the transmitted power and torque. For an input torque of 102 Nm at the pedal shaft and a pedal sprocket with 18 teeth (Pitch Diameter ≈ 0.073 m), the chain force is calculated using Equ(6):

$$F_{chain} = \frac{Torque}{Pitch\ Radius} \quad 1.6$$

$$= \frac{102\,Nm}{0.073\,m} \approx 2800\,N$$

The ultimate strength of ANSI #40 chain is over 18 kN, providing a high safety factor against fracture.

The vertical members of the frame (Frame Members (Vertical Supports) are critical as they carry the compressive load from the pressing reaction force. A maximum axial pressing force (F) of 10 kN was estimated. For a 40x40x3 mm RHS (A=444 mm²) made of ASTM A36 steel (Sy=250 MPa), the compressive stress is calculated using Equ (7):

$$\sigma = \frac{F}{A} \quad 1.7$$

$$= \frac{10{,}000\ N}{4.44\ x\ 10^{-4} m^2}$$

$$= 22.5\ MPa$$

This is well below the yield strength. Furthermore, the column was checked for buckling using Euler's formula. With a length (L) of 0.8 m and a minimum moment of inertia (I) of 1.15 x 10^{-7} m^4, the critical buckling load (P_cr) for a fixed-free column is:

$$P_{cr} = \frac{(\pi^2 * E * I)}{4 * L^2} \quad 1.8$$

$$= \frac{(\pi^2 * 200\ GPa * 1.15\ x\ 10^{-7} m^4)}{4 * (0.8\ m)^2} \approx 88\ kN$$

The factor of safety against buckling is 88 kN / 10 kN = 8.8, indicating the frame is very stable as shown in (Fig. 5).

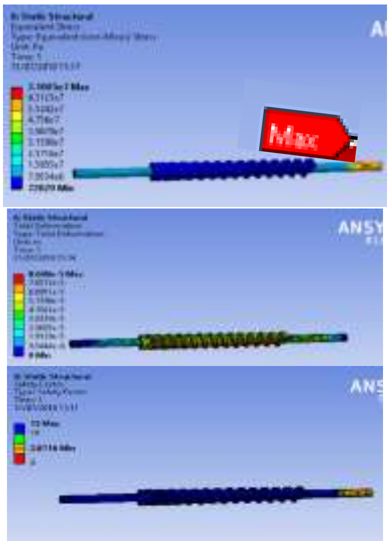
In the selection of the ball bearings (UC 204 series) on the main screw shaft were selected based on their dynamic load rating (C = 12.8 kN). The equivalent dynamic load (P) from the axial pressing force (10 kN) was calculated. The bearing life was estimated to be far in excess of the machine's service requirements, confirming the selection.

2.6. Finite Element Analysis (FEA) Validation

The screw shaft was modeled in CATIA V5 and analyzed using ANSYS 18.1 to validate the hand calculations and identify stress concentrations. A torque of 45 Nm and an axial compressive force of 5 kN (estimated from the pressing pressure) were applied. The FEA results (Fig. 4) confirmed a maximum von Mises stress of 71 MPa, which is significantly below the yield strength of the selected AISI 1045 steel, providing a minimum safety factor of 7.5 and confirming a robust design.

Figure 4

Results of the Finite Element Analysis (FEA) for the Screw Shaft

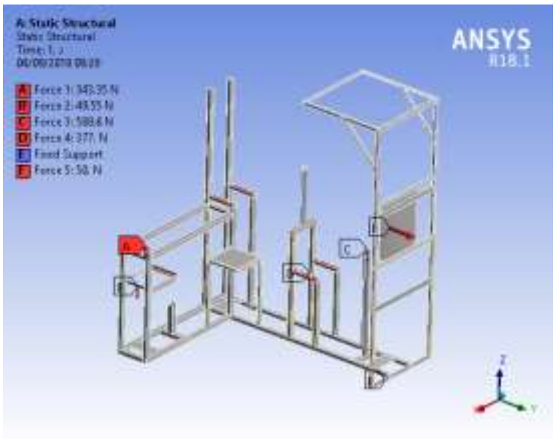


Note. The figure revealed that the Equivalent (Misses stress) of screw shaft (a), total deformation of screw shaft (b), and factor of safety.

Frame Analysis: a static structural analysis was performed on the frame with the calculated loads shown in **Figure 6** which is acceptable for the base material, and minimal deformation.

Figure 5

Weights and Loads Applied on Frame



2.7. Prototype Fabrication

A full-scale functional prototype was fabricated in a local workshop to demonstrate the feasibility of local manufacturing as shown in **Figure 6**. The materials and fabrication processes are detailed below:

Frame: the main skeleton was constructed from ASTM A36 mild steel rectangular hollow sections (40 mm x 40 mm x 3 mm wall thickness). All joints were welded using a shielded metal arc welding (SMAW) machine.

Screw Shaft: the central screw was identified as a critical component. To ensure food safety and mechanical strength, it was machined from a 30 mm diameter AISI 1045 medium carbon steel round bar. The screw profile, with a pitch decreasing from 12.5 mm to 0 mm over its 560 mm length, was precision-cut on a center lathe. The surface was polished to a smooth finish to minimize oil adhesion.

The extraction barrel was fabricated from a seamless ASTM A213 TP304 stainless steel pipe with an internal diameter of 62 mm. This material was selected for its corrosion resistance and to prevent contamination of the edible oil. Oil drainage holes of 2 mm diameter were drilled in a staggered pattern using a pillar drilling machine.

Power transmission: a standard ANSI #40 roller chain and sprockets (18 teeth on the drive sprocket, 45 teeth on the driven sprocket) were used. The system was mounted on shafts supported by double-row ball bearings (UC 204 series).

Quality Control: critical dimensions, such as the screw shaft diameter and barrel inner diameter, were verified using a digital Vernier caliper. The concentricity of the shaft and barrel assembly was carefully adjusted to ensure smooth operation.

Figure 6

The Fabricated Prototype of the Pedal-Powered Sesame Oil Extraction Machine

2.8. Experimental Setup and Performance Evaluation

2.8.1. Materials and Pre-processing

Whitish Humera-type sesame seeds were procured from local markets. A standardized pre-processing protocol was established: seeds were cleaned (sieving, washing), dried, roasted at a controlled temperature (120°C), and mechanically ground (Figure 7).

Figure 7

Seed Preparation Stages

2.8.2. Choice of Factors

Based on a comprehensive literature review (Akinoso et Al., 2006; Elkhaleefa et al., 2015; Olayanju et al., 2006), three critical parameters were selected: particle size, roasting time, and moisture content. The levels for these factors were chosen to reflect practical and effective ranges for sesame oil expression. Particle sizes of 1.0 mm and 1.5 mm were selected to evaluate the effect of cell rupture. Roasting times of 10 and 15 minutes at 120°C were chosen to denature proteins and reduce oil viscosity. Moisture content levels of 8% and 10% were selected based on the typical range where water acts as a lubricant without causing slippage.

2.8.3. Experimental Design

A Design of Experiments (DoE) approach using a Taguchi L8 (2^3) orthogonal array was employed. This design was chosen for its efficiency, allowing the study of three parameters with only four experimental runs instead of the full factorial eight, making it resource-effective while still providing valid data on the main effects of each parameter (Ross, 1996). The experimental design is shown below.

Table 1
Taguchi L8 (2^3) Orthogonal Array defining the experimental runs

Experiment No	Control variables (parameters)		
	Roasting time(min)	Particle size(mm)	Moisture Content (%)
1	10	1	8
2	10	1.5	10
3	15	1	10
4	15	1.5	8

2.8.4. Performance Metrics

For each experiment, 1 kg of conditioned seeds was processed, and the following metrics were calculated using Equ(9) to Equ(12):

$$Oil\ Extraction\ Ratio\ (OER), \%: \ OER = \frac{Woil}{Wseeds} \times 100 \quad 1.9$$

$$Oil\ Extraction\ Efficiency\ (OEE), \%: \ OEE = \frac{OER}{OilContent} \times 100 \quad 1.10$$

$$Machine\ Capacity\ (MC), \frac{kg}{h}: \ MC = \frac{Wseeds}{Time} \quad 1.11$$

$$Extraction\ Rate\ (ER), \frac{L}{h}: \ ER = \frac{Voil}{Time} \quad 1.12$$

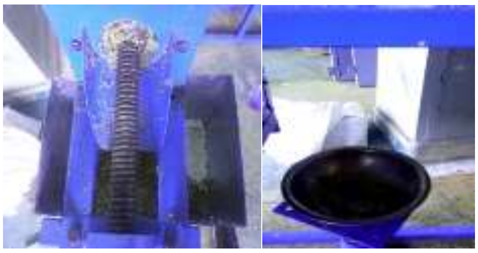
4. Results and Analysis

3.1. Prototype Performance

The POSOE prototype was successfully operated, demonstrating stable and continuous extraction. The extracted oil was collected via a drainage flange into a tank, while the residual cake was discharged as flakes (**Figure 8**).

Figure 8

Outputs from the POSOE



Note. (a) Sesame seed cake; (b) Filtered sesame oil

The performance results for the four experimental trials are summarized in **Table 2.** The overall average performance of the machine was determined to be 62% OER, 19.25 kg/h MC, 7.74 L/h ER, and 31% OEE. Experiment 3 (15 min roasting, 1.0 mm particle size, 10% moisture) yielded the best results.

Table 2

Performance Evaluation Results from the Taguchi L8 Experimental Design

Control Variables	Level	Result Of Combination Of Variables			
		Extraction rate (l/hr)	Oil yield (%)	Oil extraction efficiency (%)	Machine capacity (kg/hr)
Roasting time	10	7.00	56.5	28.23	19.26
	15	8.49	68.5	34.03	19.26
Particle size	1	7.80	60.32	30.16	20.00
	1.5	7.69	64.19	32.09	18.52
Water content	8	7.09	57.23	28.61	19.26
	10	8.40	67.8	33.64	19.26

3.2. Analysis of the Effect of Operational Parameters

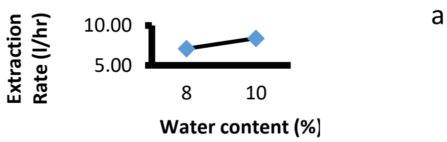
The main effects of the three operational parameters on the performance metrics are detailed below.

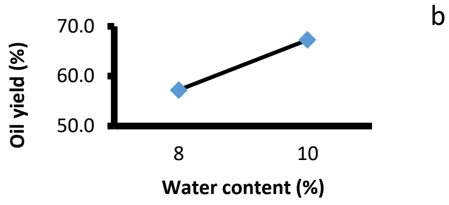
3.2.1. Effect of Moisture Content

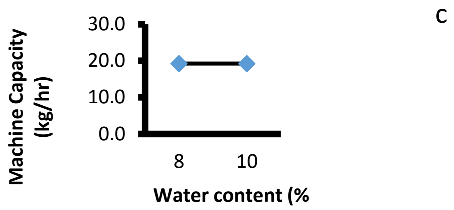
Figure 10 illustrates that increasing the moisture content from 8% to 10% led to a marked improvement in oil yield, extraction rate, and efficiency. This is attributed to the lubricating effect of water, which reduces the internal friction of the seed meal, facilitating the flow of expressed oil through the press cake. Machine capacity remained constant, as it is primarily a function of the machine's design and feeding rate.

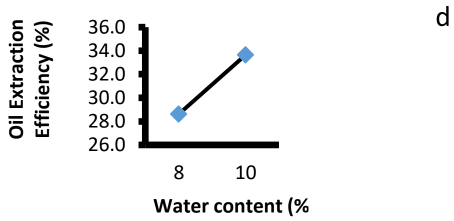
Figure 9

Main Effects Plot Showing the Influence of Moisture Content on Key Performance Indicators (a-d)





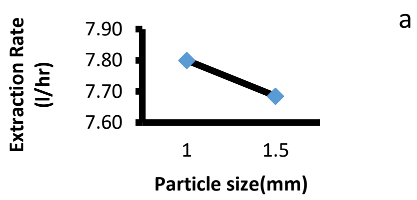


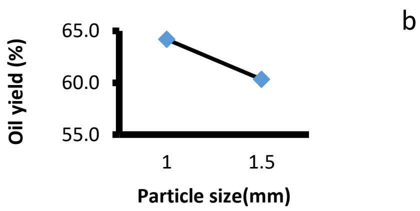


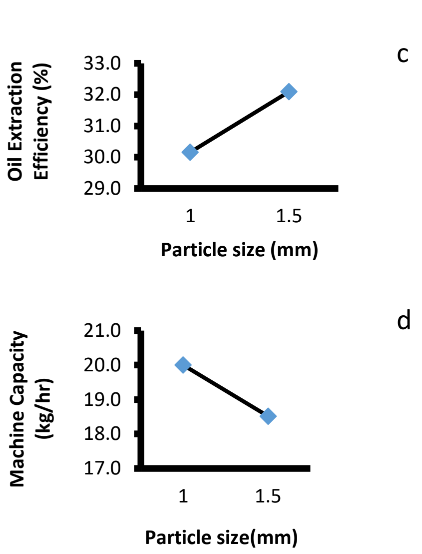
3.2.2. Effect of Particle Size: As shown in **Figure 10**, a smaller particle size (1.0 mm) consistently resulted in better performance across all metrics compared to a larger size (1.5 mm). Finer grinding increases the surface-area-to volume ratio, ruptures a greater proportion of oil cells, and creates more channels for oil to escape, thereby enhancing extraction.

Figure 10

Main Effects Plot Showing the Influence of Particle Size on Key Performance Indicators (a-d)







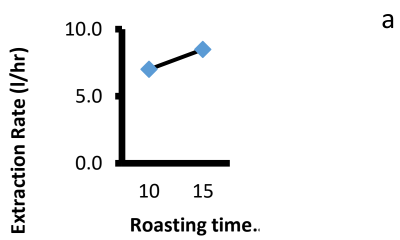
Note. Particle size versus extraction rate (a), Particle size versus oil yield (b), Particle size versus oil extraction efficiency(c), and Particle size versus Machine capacity (d)

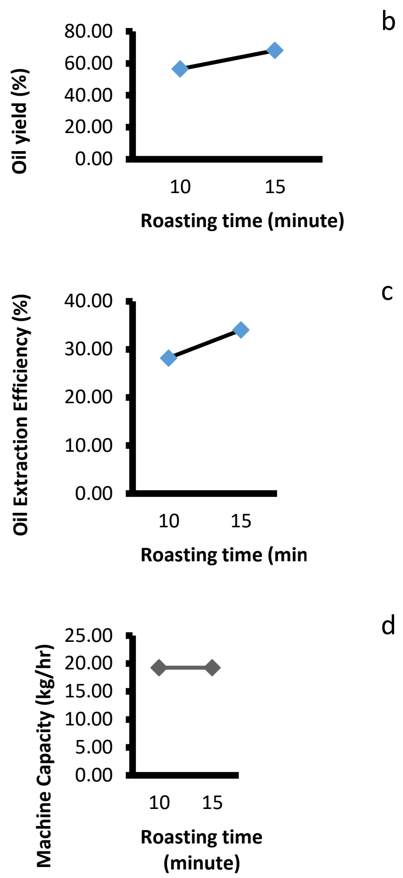
4.2.3. *Effect of Roasting Time*

Figure 11 demonstrates that a longer roasting time (15 min) significantly boosted the oil yield, extraction rate, and efficiency. Thermal treatment during roasting reduces oil viscosity, denatures oil-binding proteins, and disrupts cellular structures, thereby liberating more oil during the mechanical pressing stage.

Figure 11

Main Effects Plot Showing the Influence of Roasting Time on Key Performance Indicators (a-d)





Note. Roasting time versus extraction rate (a), Roasting time versus oil yield (b), roasting time versus oil extraction efficiency(c), and Roasting time versus machine capacity (d)

Based on the main effects analysis, the optimum condition for maximizing oil yield is (1.0 mm particle size), (15 min roasting time), and (10% moisture content). The results from experiment 3 confirms this, yielding the highest oil yield of 68.05% and efficiency of 34.03%.

4. Discussion

This study successfully demonstrates the viability of human-powered machinery as an appropriate technology for small-scale agro-processing. The POSOEM represents a significant technological upgrade over existing manual methods without incurring the high costs and operational complexities of motorized systems.

The performance results align well with the principles of mechanical oil expression. The positive correlation between oil yield and roasting time/particle size is consistent with previous research on oilseeds (Akinoso et Al., 2006; Tunde-Akintunde et al., 2012) The optimal moisture content of 10% found in this study acts as a plasticizer and lubricant, reducing the energy required for compression and improving oil flow, a phenomenon also observed in other oilseeds (Aremu et Al., 2016).

The most significant finding is the trade-off between extraction yield and processing capacity. Although the POSOEM's maximum oil yield (68.05%) is lower than that of some traditional methods (73-75%), its revolutionary advantage lies in its dramatically higher throughput. For a small-scale processor, the ability to process over 19 kg of seeds per hour compared to 3.8-5 kg/hr fundamentally alters the economics of the operation, enabling higher daily production and income. The lower yield can be potentially mitigated by optimizing the screw's compression ratio or implementing a two-stage pressing system in future iterations.

From a sustainable development perspective, the POSOEM scores highly. It requires zero operational energy cost, utilizes locally sourced materials and fabrication skills, and is designed for repair and maintenance with basic tools. Furthermore, it provides a source of physical activity and can be deployed in the most remote, off-grid communities. The residual cake, a nutritious by-product, can be utilized as animal feed, creating an additional revenue stream. At a cost less than 90,000 ETB, it presents an affordable and rapid return on investment for small-scale entrepreneurs.

5. Conclusion

This project has concluded in the development of a fully functional, engineered solution for small-scale sesame oil extraction. The Pedal-Powered Sesame Oil Extraction Machine (POSOEM) has been proven to be a robust, safe, and efficient machine that effectively addresses the core limitations of traditional methods. Its design, validated through engineering analysis and practical testing, prioritizes manufacturability, usability, and economic viability. The machine achieved a maximum oil yield of 68.05% and an average processing capacity of 19.25 kg/hr. The optimal processing parameters were identified as a roasting time of 15 minutes, a particle size of 1.0 mm, and a moisture content of 10%. By increasing processing capacity by over 300% without relying on fossil fuels or electricity, the POSOEM has the potential to significantly enhance productivity, profitability, and self-sufficiency in rural sesame-producing communities in Ethiopia and beyond.

Based on the findings of this study, the following recommendations are made:

For Researchers: Future work should focus on a full factorial or Response Surface Methodology study to model interactions between parameters and conduct a detailed analysis of the oil's chemical properties.

For Enterprises and Fabricators: To commercialize the POSOEM, attention should be paid to using food-grade stainless steel for all oil-contact surfaces to maintain oil quality and prevent contamination. A quick-disassembly mechanism for the screw and barrel should be incorporated for easier cleaning.

For Government and NGOs: Policies and programs that promote and subsidize such intermediate technologies can accelerate local value addition in the agricultural sector, reduce post-harvest losses, and create rural employment.

6. Future Work

The present thesis work explores the design, manufacturing and performance testing of the POSOEM. However, it leaves a wide area for future research:

1. A detailed study on the physicochemical properties of the extracted oil under different processing parameters.
2. Integration of a solar-powered electric motor to assist the pedaling operation, reducing operator effort and further increasing capacity.
3. Re-design of the screw assembly with a quick-release mechanism to facilitate faster cleaning and maintenance.
4. Exploration of the machine's performance with other high-value oilseeds native to Ethiopia.

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