IOCIV 2026 Conference
The 1st International Online Conference on Inventions
25–26 June 2026 | Online
MDPI

Exploring Wild *Arachis pintoi* Biomass for Sustainable Bioenergy: A Multi-Product Strategy for Biofuel Production

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INTRODUCTION & AIM

Arachis pintoi **(Pinto Peanut)** is a perennial leguminous ground-cover plant with oil-rich seeds and abundant biomass, offering significant potential as a renewable energy feedstock. Through an integrated biorefinery approach, its biomass can be converted into multiple value-added products, including biodiesel, bio-oil, syngas, biochar, and briquettes, contributing to sustainable energy production and circular bioeconomy development. However, the bioenergy potential of wild *A. pintoi* remains largely unexplored, and comprehensive studies integrating both seed and shell biomass for the production of diverse renewable energy products are currently lacking.

OBJECTIVES

Broad Objective

To evaluate the suitability of wild *Arachis pintoi* biomass as a sustainable feedstock for integrated biofuel production through a multi-product biorefinery approach.

Specific Objectives

- Extract and characterize oil from *Arachis pintoi* seeds.
- Produce biodiesel and evaluate its fuel properties.
- Convert shell biomass into bio-oil, syngas, and biochar through pyrolysis.
- Produce densified briquettes from shell residues.
- Assess the physicochemical and energy properties of all products.

METHOD

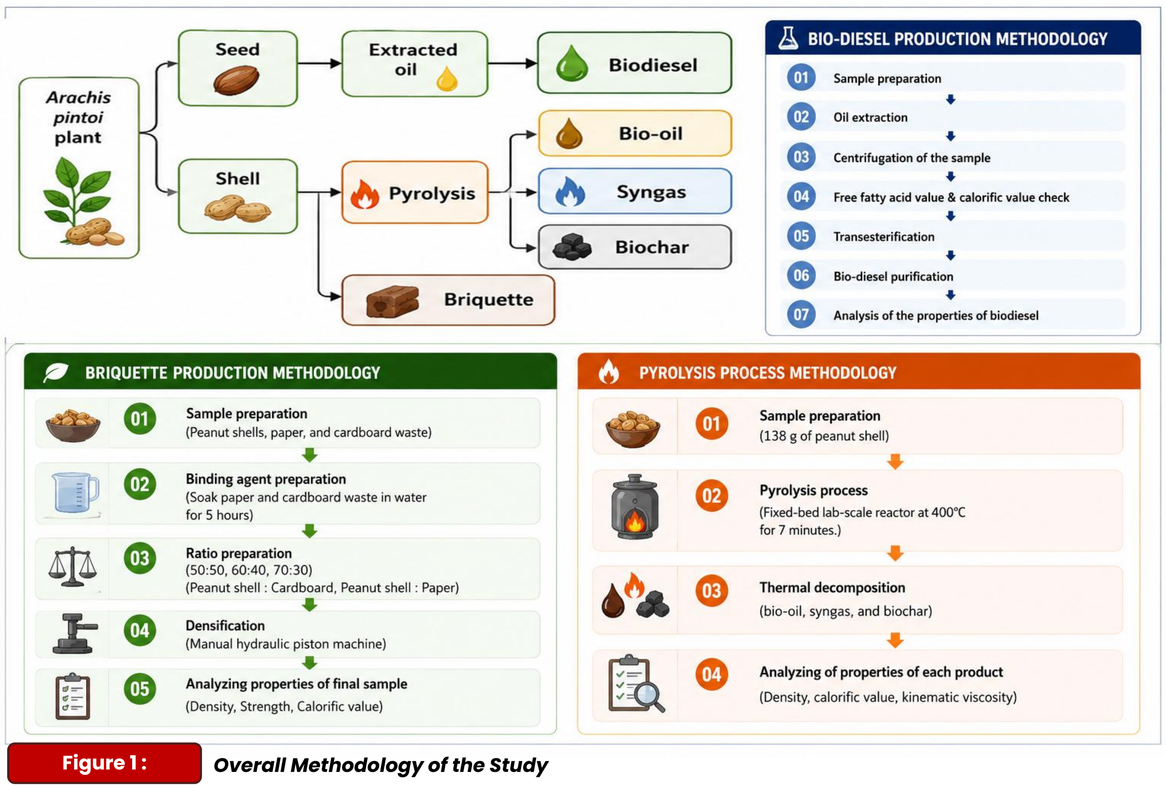


Figure 1: ***Overall Methodology of the Study***

RESULTS & DISCUSSION

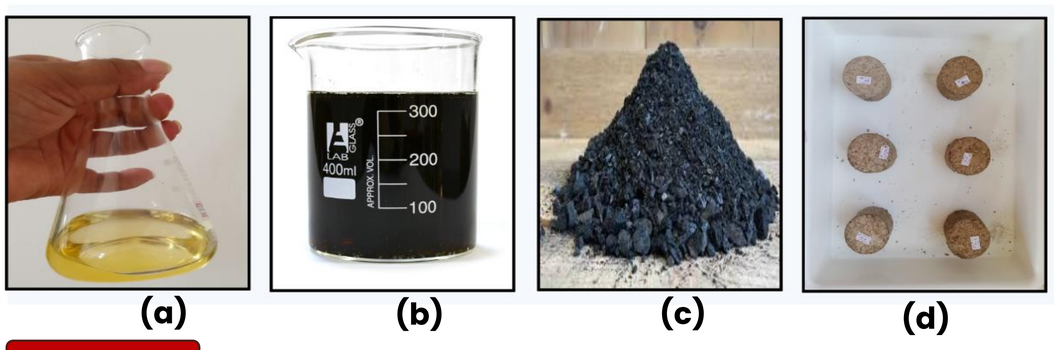
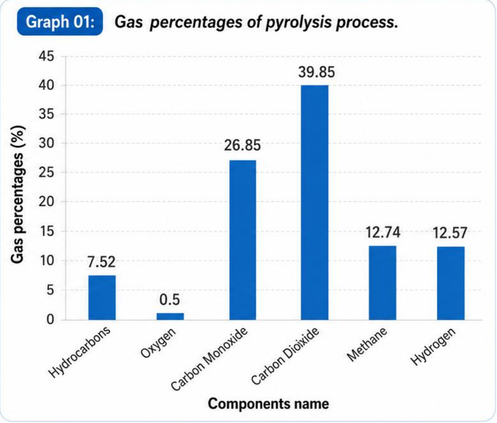


Figure 2: ***Product of Bio diesel(a), Bio oil (b), Bio char(c) and Briquette (d)***

Table 1: *Comparison of biodiesel properties with ASTM standard.*

Properties of fuel	Arachis pintoi Biodiesel Sample	ASTM Standard (D6751) Biodiesel Sample
Calorific Value (MJ/kg)	40.54	40.5
Density (15°C) (g/cm³)	0.86	0.87 – 0.89
Kinematic Viscosity (40°C) (mm²/s)	4.70	1.9 – 6.0
Flash Point (°C)	157.5	93°C
Thermal Conductivity (mW/m·K) at 30.15°C	140.56	N/A

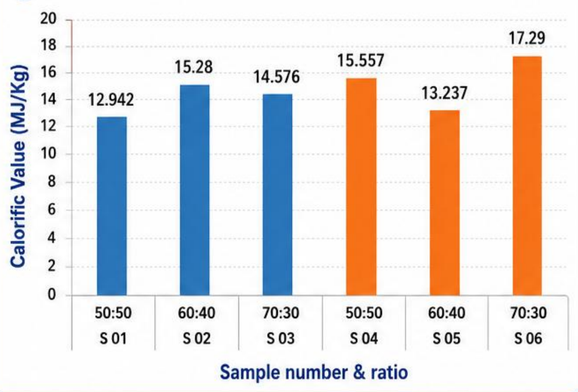
Graph 01: *Gas percentages of pyrolysis process.*



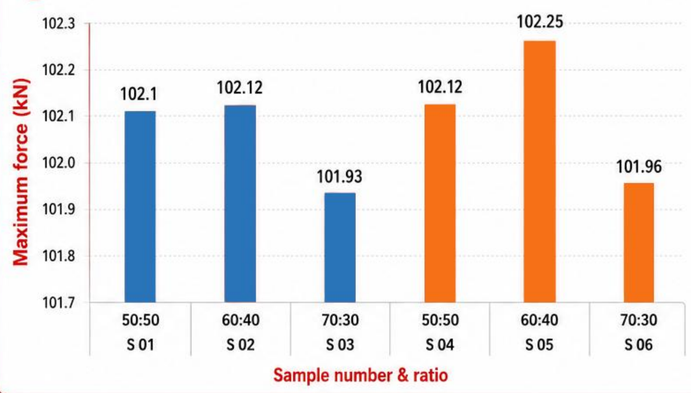
❖ **The calorific value of syngas production – 4.22 MJ/m³**

Calorific Value of Products

Graph 02: Calorific value of briquette samples



Graph 03: Maximum force of briquette samples



Graph 04: Density of briquette samples

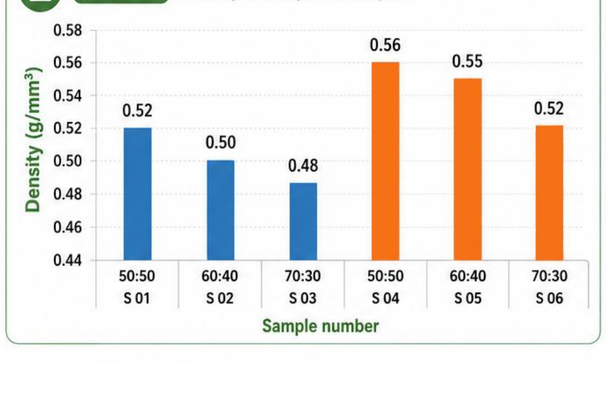


Table 02: *Comparing peanut shell with other crop pyrolysis oil*

Properties of bio-oil	Peanut shell bio-oil	Woody biomass bio-oil	Microalgae bio-oil
Density (40 °C) g/cm³	0.97	1.2	1.16
Kin. viscosity (40 °C) (Pa/s)	0.03	0.04 - 0.20	0.10
Calorific value (MJ/Kg)	46.43	21	29

KEY FINDINGS

- FFA content of seed oil: 0.612%
- Biodiesel conversion efficiency: 84%
- Biodiesel met ASTM D6751 standards: COMPLIANT
- Syngas calorific value: 4.22 MJ/m³
- Bio-oil calorific value: 46.43 MJ/kg
- Biochar calorific value: 25.24 MJ/kg
- Near-zero waste biomass utilization: SUSTAINABLE

❖ The exceptionally low FFA content (0.612%) of *Arachis pintoi* seed oil enabled direct alkaline transesterification without acid pretreatment, reducing processing complexity and production costs. The resulting biodiesel exhibited favorable fuel properties, including a calorific value of 40.54 MJ/kg, kinematic viscosity of 4.70 mm²/s, and flash point of 157.5°C, demonstrating compliance with ASTM D6751 biodiesel standards.

❖ Pyrolysis of shell biomass at 430°C successfully produced syngas, bio-oil, and biochar, highlighting the potential for complete biomass valorization. The syngas contained appreciable methane (39.85%) and hydrogen (12.57%) concentrations, indicating suitability for thermal energy applications. The bio-oil exhibited a high calorific value (46.43 MJ/kg), while biochar showed enhanced energy density (25.24 MJ/kg) compared with raw shell biomass (16.79 MJ/kg).

❖ These findings demonstrate that both seed and shell fractions of wild *Arachis pintoi* can be effectively utilized through an integrated biorefinery approach, maximizing resource efficiency and supporting sustainable renewable energy production.

CONCLUSIONS

❖ Wild *Arachis pintoi* seed oil exhibited a low FFA content (0.612%), enabling direct alkaline transesterification and resulting in an 84% biodiesel conversion efficiency.

❖ The produced biodiesel possessed favorable fuel properties (40.54 MJ/kg calorific value, 4.70 mm²/s viscosity, and 157.5°C flash point) and complied with ASTM D6751 biodiesel standards.

❖ Pyrolysis of *Arachis pintoi* shell biomass successfully generated syngas, bio-oil, and biochar, demonstrating the effectiveness of thermochemical conversion for energy recovery.

❖ The produced syngas (4.22 MJ/m³), bio-oil (46.43 MJ/kg), and biochar (25.24 MJ/kg) exhibited considerable energy potential, highlighting the suitability of shell biomass for renewable fuel production.

❖ The integrated utilization of both seed and shell fractions demonstrates that wild *Arachis pintoi* is a promising feedstock for sustainable multi-product bioenergy production and circular biorefinery applications.

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This Study is supported by the STHRD Project, Ministry of Education, Sri Lanka, funded by the Asian Development Bank (ADB) through Grant No. CRG/R3/SB6.