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Energy

PRODUCTION OF BIODIESEL FROM CASHEW-NUT SHELL

Shaurya Singh

Chiranjiv Chaudhary

Kritika Mourya

Sandeep Kumar

ABSTRACT Cashew nut is a tropical and subtropical region plant which fulfil the increased demand for alternative energy sources and the price of the environment as a result of the use of traditional fossil fuels has sparked interest in the production of biodiesel from renewable biomass feedstocks. The present scenario demands the production of biodiesel from cashew nut shell, a cheap forest agro-waste yet to be utilized to its full potential. Cashew nut shells are extremely oily (44-48%) and thus a good feedstock for the production of biodiesel approximately (85.43%). The process is solvent extraction of oil from cashew nut shell followed by transesterification with an alkaline catalyst to yield biodiesel. The product biodiesel was compared and differ from the standard diesel fuel specifications in terms of viscosity, density, and calorific value. The conclusions are that biodiesel from cashew nut shell has good properties and thus is a suitable renewable fuel source. The environmental advantages of using 'agro-waste, such as waste disposal problems minimization and reduction of greenhouse gas emissions. The use of cashew nut shell to produce biodiesel on a commercial scale is also stated to be economically viable, pointing out the advantage of having a sustainable, green energy source. Generally, cashew nut shell gives a satisfactory alternative to produce biodiesel to contribute towards diversification of renewable power and mitigating fossil fuel dependency.

KEYWORDS : Biodiesel, Cashew nut shell, Transesterification, Renewable energy, Argo-waste, Sustainable energy, Environmental impact.

INTRODUCTION:

The increasing demand for energy and decreasing fossil reserves has prompted scientists to explore alternative renewable energy sourcing. Biomass offers potential because it is renewable and generally regarded as carbon neutral. Pyrolysis is an efficient process to derive energy from biomass. Because pyrolysis produces liquid fuel and important chemicals, it represents another pathway to energy sustainability. In addition, (biomass) pyrolysis is a process by which energy can be obtained from biomass through heating biomass in an inert atmosphere at a high (generally > 400ºC) temperature to generate bio-oil, biochar, and non-condensable gases (also called syngas). Climate change is mainly caused by the combustion of fossil fuels, and removing fossil fuel use has to be the foundation for any effort to create a carbon neutral society **(Lund et al., 2022)**.Presently, approximately 1000 barrels of fossil fuel is combusted every second, and the current trend in unregulated fossil fuel use is pitifully large contributor to the global warming phenomenon through the continuous release of greenhouse gases into the atmosphere. If the Earth's temperature rises more than 2°C, millions of people will perish and approximately a million species will be on the edge of extinction. The elimination of fossil entails that both developed countries and advancing emerging markets have to invest in improving energy efficiency and reducing dependency on imports while simultaneously encouraging the use of alternate environmentally friendly energy sources. Cashew trees can be found in many regions of the world, including the Amazon basin and Tanzania, Brazil, Malawi, Senegal, Thailand, Sri Lanka, India, Angola, Kenya, Mozambique, Nigeria, and Indonesia. Côte d'Ivoire is leading world production of cashews with a production of over 1.25 million tons and India and Tanzania are also making a significant contribution to world production. Vietnam and Cambodia are also facing challenges in production due to climate condition; however, India has continued to maintain its production capacity and Tanzania has an exceptional year. In 2025 Côte d'Ivoire is challenging to remain the leader in production followed by India and the Vietnam **(Pushparaj and Ramabalan, 2024).**

The cashew tree was brought to India by Portuguese missionaries in the 1400s **(Das et al., 2003)**. There are a lot of reasons for the tree's widespread cultivation. Not only do individuals harvest kernels, apples, nuts, and timber from the cashew tree---individuals also make a value designation to harvest the waste part of the cashew tree as the shell; while having discovered the environmental damage it is causing to many countries **(Abrego et al., 2018).** The cashew nut has a hard structure in the form of a shell (also referred to as hard shell), and is abundantly disposed of incorrectly **(Jeyavishnu et al., 2021).** Typically, cashew nut shells are composed of one of the following components: 10.80% water, 2.60% ash, and average moisture 6.47% moisture content, **(Jeyavishnu et al., 2021).**

Cashew Nut Shell: Availability And Composition:

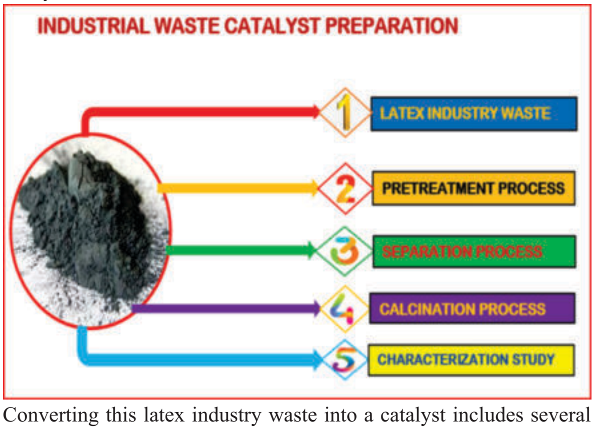
Table-1: Global Availability.

Country	Production of cashew-nut per year (MT)	Production of cashew-nut shell liquid per year (MT)
India	~750000	~225000
Nigeria	~650000	~200000
Vietnam	~600000	~180000
Brazil & Ivory coast	~500000	~150000

Note- Potential biodiesel yield: From every 1-ton cashew-nut shell-250-300 Liters biodiesel equivalent.

Uses Of Cashew-nut Shell, Cashew-nut Shell Liquid, And Industrial Waste:

Preparation of industrial waste from heterogeneous catalysts in the latex industry involves coating products like condoms and gloves with coating powder. This coating makes them easier to unwrap. After coating, these products are dipped in a water solution. The powder that washes off becomes industrial waste. This waste is sometimes used in cement production, but it can also be processed into a useful dolomite catalyst.



Converting this latex industry waste into a catalyst includes several steps. These waste solution, which contains various chemicals and solid particles, first undergo pre-treatment starts neutralization is often needed.

Table-2: Physiochemical Properties Of Raw Vs. Calcinated Dolomite.

Properties	Raw dolomite	Calcinated dolomite (~800°C)	Key change
Crystal phase (XRD)	Primarily CaMg (CO3)2 with some calcite.	Predominantly CaO (cubic) and MgO (cubic).	Decarbonation increases catalytic activity.
Elemental composition (XRF/EDX)	Ca, Mg, O, and C are present. Example: Ca~41%, Mg~C~7%20% , O~28%.	C is significantly reduced. Example: Ca~41%, Mg~20%, O~39%.	Removal of carbonate ions confirms successful calcination.
Surface area (BET)	Low surface area (~4-5 m²/g).	Significantly increased surface area (~15-20 m²/g).	Higher surface area provides more active sites for reaction.
Pore volume (BJH)	Low pore volume (<0.05 cm³/g).	Higher pore volume (~0.1-0.2 cm³/g).	Increased porosity allows for better diffusion of reactants and products.
Basicity	Weaker basic sites inherent to carbonate minerals.	Stronger and more abundant basic sites from CaO and MgO.	Increases efficiency for base catalysed reaction like transesterification.
Morphology (SEM)	Dense, block-like particles with sharp edges and low porosity.	High-porosity structure with aggregated, irregular and clustered particles.	Increased porosity enhances catalytic performance.

After the valuable materials are extracted, the next step is calcination. During calcination, a heat treatment, the mixture is heated to an elevated temperature (800°C). The heat treatment connected the carbonate to magnesium and calcium in their activated oxide forms. The heating also increases the catalytic properties of dolomite and provides it ready for possible industrial uses. After calcination, the dolomite catalyst is characterized. Characterization shows the catalytic capability of the industrial waste. The dolomite in transesterification is evaluated for its catalytic performance and efficiency during CSLB production testing.

Cashew Nut Shell Liquid:

CNSL and its components have been used in many studies to create environmentally friendly products because they are a natural and renewable resource **(Maia *et al*., 2015; Zombe *et al*., 2022)**. From a chemical perspective, CNSL phenolic lipid mixtures are an ideal starting point for various chemical reactions. They possess aromatic rings, polar functional groups, and double bonds on their side chains. These mixtures have been used to produce insecticides, germicides, antioxidants, thermal insulators, friction materials, plasticizers, surfactants, paints, resins, and varnishes **(Paula *et al*., 2022)**. CNSL is also used to make polyols and polyurethanes, and it serves as a bio additive to help lessen the environmental impact of crude oil fuels **(Jeyavishnu *et al*., 2021)**.

Utilization Of Cashew-nut Shell:

Cashew Nut Shell Liquid (CNSL) is a renewable, cost-effective byproduct from the shells of cashew nuts.It has active phenolic compounds - cardanol, cardol, and anacardic acid. CNSL has a great many industrial applications for the production of heat-resistant paints, adhesives, varnishes, brake linings, and rubber chemicals **(Kandaswamy, S. et al. 2023).** Its great chemical reactivity, thermal stability, and binding characteristics make it valuable for those applications.

CNSL has natural pesticide and fungicide qualities which makes it useful in agriculture. as well as in the medical sector where studies are being conducted to explore its value in therapeutics from its antimicrobial, antioxidant, and anti-inflammatory properties. CNSL is gaining popularity in the development of eco-friendly fuels and bio-based chemicals. It is also invaluable for developing coatings that prevent corrosion in marine or industrial applications. CNSL has enormous potential for supplying sustainable, green alternatives across various sectors.

CSLB Production (Cashew-nut shell liquid):

CSLB production and its properties evaluation

The CSLB is extracted from agro-waste liquid derived from cashew nut shells using a transesterification process. First, the liquid is obtained from the waste cashew nut shells, through a mechanical pressing operation. Next, a magnetic stirrer stirs one litre of the extracted CSL after it is heated to 70 °C. Then, a methanol/CSL molar ratio of 20:1 and 4 wt.% of a catalyst made from industrial waste are added to the CSL flask. **(Devaraj *et al.* (2020).**

Current Scenario Of Biodiesel Production In India:

India's biodiesel production is on the rise, largely due to the country's National Policy on Biofuels and commitment to reduce dependence on fossil fuel, though capacities typically exceed operational levels due to factors such as feedstock prices and domestic level of demand. India is also beginning to focus on the use of non-edible oils and waste cooking oil as feedstock to lessen the food-vs-fuel conflict which will eventually provide some clarity around feedstock input for biodiesel processors. Challenging issues for India continue to be growing domestic demand for blends through government mandates, waste feedstock collection, and improving the supply chain for feedstocks. **(Gard (2025) and VPS (2025).** India is also the co-chair of the Global Biofuel Alliance, founded in 2023, which will support advancement of biofuel technologies and trade to reduce dependence on fossil fuels globally. The National Policy on Biofuels in India provides a framework to accelerate growth in biodiesel through subsidies, price guarantees, long-term contracts and funding for research in advanced biofuels. Biodiesel feedstock applications are currently limited to only select Oil Marketing Companies (OMCs), Indian Railways, and select road transport corporations.

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