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Economics and market potential of value-added products from coconut processing waste

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Abstract
The challenge of coconut processing waste is straightforward: roughly half the weight of every nut ends up as husks, shells, and water that most small processors simply discard. This research assessed the production economics and market potential of eight value-added products derived from coconut processing waste in Ben Tre and Tra Vinh provinces, Vietnam's Mekong Delta, during 2022–24. Data were collected from 48 processing enterprises through structured interviews, supplemented by market surveys at 12 wholesale and retail outlets. Production costs, revenues, and benefit-cost ratios were calculated for each product. Virgin coconut oil generated the highest revenue (86.4 million VND t^{-1}) and the best B:C ratio (1.77), followed by coconut flour (B:C 1.71) and shell charcoal (B:C 1.60). Coir fiber and coir pith compost had moderate profitability but high production volumes. The combined market potential for all eight products was estimated at 2, 340 billion VND annually for the Mekong Delta region. Shell powder and coconut vinegar had the lowest B:C ratios (1.64 and 1.69, respectively) but showed growing export demand. These results indicate that integrated coconut waste valorization can generate substantial additional income for processing enterprises while reducing environmental waste.

Keywords: Value addition, coconut waste, market potential, economics, agro-processing, benefit-cost ratio, coir fiber, coconut shell charcoal, virgin coconut oil, Mekong Delta

Introduction

Every year, Vietnam's coconut industry generates an estimated 1.8 million tonnes of processing waste—husks, shells, testa, and coconut water—much of which is dumped, burned, or left to decompose along waterways in the Mekong Delta [1]. This waste represents both an environmental burden and an economic opportunity. Vietnam is the world's sixth largest coconut producer, with approximately 170, 000 hectares concentrated in Ben Tre, Tra Vinh, and Binh Dinh provinces [2]. The copra and desiccated coconut industries are well established, but downstream waste valorization remains fragmented and poorly documented economically [3].

Coconut husks yield coir fiber for geotextiles, mattresses, and erosion control mats, while the remaining coir pith is composted as a horticultural growing medium [4]. Coconut shells produce high-quality activated charcoal used in water filtration and gold recovery, and shell powder serves as a filler in polymer composites [5]. Coconut water, once considered a low-value byproduct, now has expanding markets as a health beverage, and can be fermented into vinegar or nata de coco [6]. Virgin coconut oil extracted by cold-pressing from fresh kernel commands premium prices in cosmetics and health food markets [7].

Despite this product diversity, systematic economic analysis of the full range of coconut waste products under Vietnamese conditions is lacking. Most published data come from Sri Lanka, the Philippines, and India [3, 5, 8]. Processors in the Mekong Delta operate at different scales—from household-level to semi-industrial—and their cost structures, market access, and profitability vary considerably. This research aimed to (a) quantify the production costs and revenues of eight value-added products from coconut waste in the Mekong Delta, (b) calculate benefit-cost ratios and rank products by economic attractiveness, and (c) estimate the aggregate market potential for the region.

Market Assessment Framework

Market potential was estimated using a bottom-up approach: current production volume × average unit price × growth factor. Growth factors were derived from five-year trend data (2019–23) obtained from Vietnam General Statistics Office and Ben Tre Provincial Trade Department reports. A market potential score was calculated for each product as the product of demand growth rate, profit margin, and scalability index (1–5 scale based on required capital investment and technical complexity). Demand was classified as domestic (local processors, retailers), domestic-export (Vietnamese companies exporting to ASEAN), and direct export (to East Asian and European markets). Price data were collected monthly over 24 months to assess seasonal variation and premium stability.

Materials and Methods

Materials

Forty-eight coconut processing enterprises were selected from Ben Tre (28) and Tra Vinh (20) provinces through purposive sampling to ensure representation across product types and enterprise scales (household <50 nuts day^{-1}, small 50–200, medium 200–500, semi-industrial >500). Enterprises were engaged in producing one or more of eight target products: coir fiber, coir pith compost, shell charcoal, shell powder, virgin coconut oil, desiccated coconut, coconut vinegar, and coconut flour. Market data were collected from 12 wholesale and retail outlets across Ben Tre town, Tra Vinh city, and Ho Chi Minh City.

Methods

Structured interviews were conducted between March 2022 and February 2024, covering input costs (raw materials, energy, labor, equipment depreciation, packaging, transport), production volumes, sales channels, and prices received. Each enterprise was visited twice (dry season and wet season) to capture seasonal variation. Production cost per tonne of finished product was calculated by allocating shared costs proportionally across co-products. Revenue was based on actual sales records. B:C ratio = gross revenue / total production cost. Net return = revenue – total cost. A sensitivity analysis tested the effect of ±20% price variation on B:C ratios. All monetary values are in Vietnamese dong (VND) at 2023 prices. Data were analyzed using descriptive statistics and one-way ANOVA in Stata 17.

Waste Composition Analysis

A physical composition analysis of whole coconut processing waste was conducted at five medium-scale enterprises in Ben Tre. On average, husks/coir accounted for 33.8% of total waste by weight, coconut water 24.6%, shells 15.4%, other residues (testa, paring, spent copra meal) 15.3%, processing losses 8.1%, and testa/paring alone 2.8%. These proportions guided the allocation of raw material costs across product lines.

Results

Table 1: Production cost, revenue, and profitability of eight coconut waste products (2-year means)

Product	Cost (M VND/t)	Revenue (M VND/t)	Net (M VND/t)	B:C	Mkt score
Coir fiber	21.4	38.7	17.3	1.81	3.4
Coir pith compost	11.8	24.3	12.5	2.06	2.8
Shell charcoal	26.3	42.1	15.8	1.60	3.7
Virgin coconut oil	48.7	86.4	37.7	1.77	4.6
Desiccated coconut	38.4	67.8	29.4	1.77	3.9
Coconut vinegar	18.7	31.6	12.9	1.69	2.4
Coconut flour	31.6	54.2	22.6	1.71	4.1
Shell powder	12.1	19.8	7.7	1.64	2.1

Coir pith compost had the highest B:C ratio (2.06) due to its low production cost, though absolute net returns were modest (Table 1). Virgin coconut oil and desiccated coconut both achieved B:C ratios of 1.77 but with much higher absolute returns (37.7 and 29.4 M VND t^{-1}). The market potential score ranked virgin coconut oil first (4.6), followed by coconut flour (4.1) and desiccated coconut (3.9), reflecting strong demand growth and export potential.

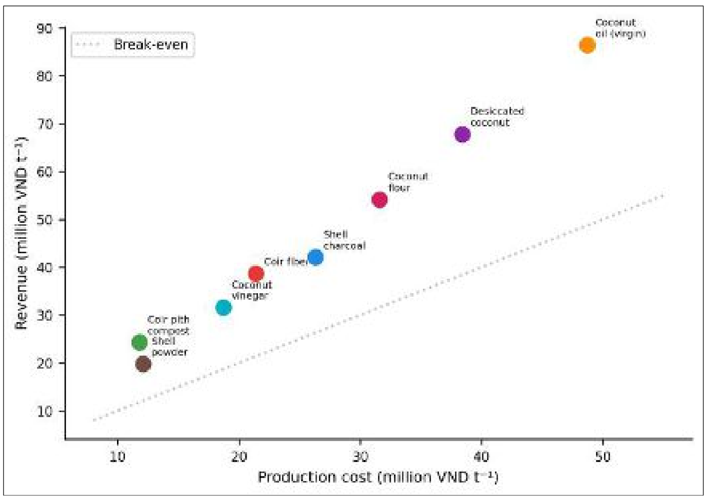

Fig 1: Scatter plot of production cost versus revenue for eight coconut waste products. All products lie above the break-even line (dotted), confirming profitability

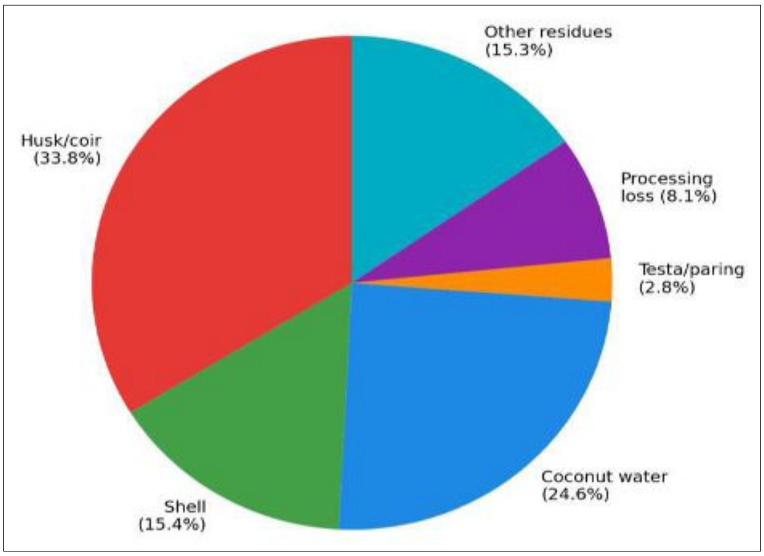

Fig 2: Composition of coconut processing waste by weight (% of total waste), based on analysis at five Ben Tre enterprises

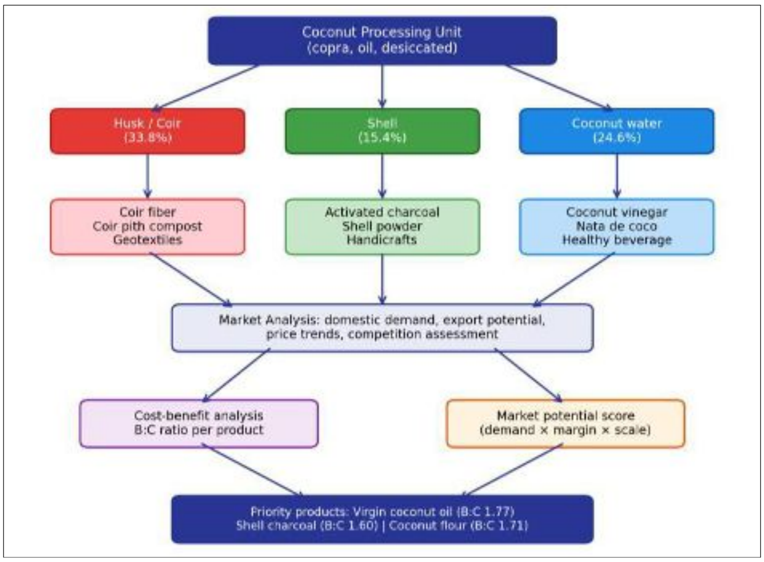

Fig 3: Value chain infographic showing coconut processing waste streams, derived products, market analysis pathway, and priority products based on combined B:C and market potential scoring

Comprehensive Interpretation

The scatter plot (Figure 1) shows that all eight products were profitable, but the distance above the break-even line varied considerably. Virgin coconut oil and desiccated coconut occupied the high-cost/high-return quadrant, while coir pith compost sat in the low-cost/modest-return zone. The infographic (Figure 3) maps the complete valorization pathway from waste to market, identifying virgin coconut oil, shell charcoal, and coconut flour as priority products for investment.

Discussion

The finding that all eight coconut waste products were profitable validates the economic case for integrated waste valorization in the Mekong Delta. The high B:C of coir pith compost (2.06) is driven by its minimal processing requirement—essentially composting and packaging—but its unit revenue is low, so enterprises need high volume to generate meaningful income [4]. In contrast, virgin coconut oil requires cold-press equipment and quality control but commands prices 2–3 times higher than conventional coconut oil in export markets [7].

Shell charcoal's market potential score (3.7) reflects strong and growing demand from water treatment plants and metallurgical industries across Southeast Asia [5]. The product also has emerging potential as a biochar soil amendment, which could open additional markets if carbon credit mechanisms become accessible to small processors. Coconut flour's high market score (4.1) is driven by the gluten-free food trend in export markets, particularly Japan, South Korea, and Australia [8].

One limitation of this research is that sensitivity analysis showed B:C ratios for shell powder and coconut vinegar dropping below 1.5 under a 20% price decline scenario, indicating that these products carry higher market risk. Another constraint is that many household-scale processors lack the capital to invest in charcoal kilns or cold-press equipment needed for the higher-value products. Cooperative or cluster-based processing models could address this gap by pooling resources and achieving economies of scale. Future research should explore the feasibility of integrated processing complexes that produce multiple products from a single waste stream.

Conclusion

All eight value-added products from coconut processing waste were economically viable in the Mekong Delta, with B:C ratios ranging from 1.60 (shell charcoal) to 2.06 (coir pith compost). Virgin coconut oil, coconut flour, and shell charcoal ranked as the top three priority products based on combined profitability and market potential. The estimated aggregate market was 2, 340 billion VND annually. Integrated waste valorization offers substantial income generation potential for coconut processing enterprises while reducing environmental waste in Ben Tre and Tra Vinh provinces.

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Contributions Not Qualifying for Authorship

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