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Quality Control in Indonesia's Coconut Supply Chain

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ABSTRACT

Indonesia holds the largest coconut plantation area globally, accounting for 3.37 million hectares or 31.2% of the world's total. Despite being the top exporter of fresh coconuts in shells, valued at USD 56 million, the country's coconut exports still have low added value. This study aims to identify the structure and quality control mechanisms of the coconut supply chain in Riau and propose recommendations for improvement. The research employed field surveys involving stakeholders across the supply chain to assess current quality control practices. The supply chain begins with farmers and collectors, leading to either the copra industry (30%) or the coconut processing industry (70%), then to the crude coconut oil (CCO) industry as an intermediate stage. After refining, this becomes Coconut Oil (CNO), which is distributed to the food (38%) and non-food sectors. Quality control practices include sorting coconuts into standard and non-standard categories at the farmer level, and classifying copra into edible (15%), regular (60%), and rejected (25%) types at the copra industry level. The study recommends formalizing coconut classification standards, ensuring copra is free from aflatoxin contamination, and increasing the added value of non-standard coconuts through downstream innovations such as Sustainable Aviation Fuel (SAF). These measures are expected to enhance product quality, support industrial diversification, and strengthen Indonesia's position in the global coconut market.

INTRODUCTION

Indonesia possesses the largest coconut plantation area globally, spanning 3.37 million hectares, which accounts for 31.2% of the world's total coconut plantation area of approximately 12 million hectares. About 98% of Indonesia's total coconut plantation area consists of smallholder plantations, with the remainder comprising state and private plantations. The average productivity of coconuts in Indonesia is 1 ton of copra per hectare per year, or 45,000 coconuts per hectare per year.

Indonesia is the second-largest exporter of coconuts and coir in the world, after the Philippines. In 2014, Indonesia's coconut export contribution reached 20.16% of the total global export value, amounting to 1.21 billion USD. In 2016, coconut and coir exports from West Kalimantan reached 43,299 tons, with export destinations including Thailand and China.

Similarly, in 2016, exports of peeled coconuts from South Sumatra totaled 149,380 tons, with the primary destinations being Thailand, China, and Vietnam.

Indonesia is the largest exporter of fresh coconuts in shells, with an export value of 56 million USD (equivalent to 784 billion IDR). However, the low selling value of this product makes it less favorable for export. Indonesia is also the second-largest exporter of desiccated coconut, after the Philippines, with exports valued at 170 million USD (equivalent to 2.3 trillion IDR). Despite having the highest export market value, the export performance of this product is challenging to improve due to high domestic consumption. Additionally, Indonesia ranks as the second-largest exporter of copra and coconut oil (CNO), including both crude coconut oil (CCO) as raw product and refined coconut oil (CNO) as processed product. In 2018, Indonesia exported raw copra valued at 354 million USD (equivalent to 4.9 trillion IDR) and processed copra valued at 368 million USD (equivalent to 5.1 trillion IDR). Major export destinations for Indonesian copra products include the Netherlands and Malaysia for raw copra and the United States and China for processed copra. Indonesia’s annual coconut production averages 15.5 billion coconuts, equivalent to 3.02 million tons of copra, 3.75 million tons of coconut water, 0.75 million tons of coconut shell charcoal, 1.8 million tons of coir fiber, and 3.3 million tons of coir dust (Allorerung and Lay, APCC, 2014). According to Hendarawati and Syamsudin AB (2016), the mass balance of processed products derived from 100 kg of coconuts is as follows: 25 kg of coir yielding 18.7 kg of coir fiber, 28 kg of coconut water producing 28 kg of nata de coco, 16 kg of coconut shell yielding 4.8 kg of charcoal briquettes, and 31 kg of coconut meat producing 5.27 kg of coconut oil, 6.51 kg of coconut powder, and 6.2 kg of desiccated coconut.

The Indonesian coconut supply chain faces persistent issues such as low farmer productivity, inconsistent product quality, and limited access to technology and infrastructure among smallholders (Arifin, 2022; Elfahmi et al., 2024; Meilizar et al., 2024). Market power is highly asymmetric, with collectors holding stronger bargaining positions that suppress farm-gate prices despite high end-market values (Wahyudi et al., 2022; Porang et al., 2024; Sanusi, 2019). Processing activities remain partly traditional and constrained by inadequate facilities, including poor sanitation and the absence of a cold chain (Taula et al., 2022; Arifin, 2022; Murtius, 2024). Heavy dependence on export markets also exposes small producers to international price volatility, while domestic absorption of value-added products such as VCO and charcoal briquettes remains limited (Simamora et al., 2016; Hestina et al., 2022).

According to BPS (2025), Riau is the largest coconut-producing province in Indonesia, with a production volume of 407.74 kilo tons and a plantation area of 442,79 hectares in 2024. Other major coconut-producing provinces include North Sulawesi, East Java, North Maluku, and Central Sulawesi. Data on coconut production and plantation areas in the ten largest coconut-producing provinces in Indonesia are presented in Table 1.

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Table 1. Major coconut-producing provinces in Indonesia (BPS, 2025)

Province	2022		2023		2024	
	Production (kilo tons)	Land area (kilo ha)	Production (kilo tons)	Land area (kilo ha)	Production (kilo tons)	Land area (kilo ha)
Riau	417.50	442.30	411.23	440.48	407.74	442.79
North Sulawesi	269.60	273.20	268.83	272.38	268.56	272.38
East Java	233.90	228.50	226.59	222.71	216.60	222.80
North Maluku	200.00	204.00	204.04	204.41	204.27	204.51
Central Sulawesi	206.20	219.30	196.21	219.31	195.05	219.23
Central Java	159.30	201.20	152.44	191.70	151.83	190.77
Jambi	114.30	115.60	114.46	115.58	115.40	115.37
North Sumatra	102.00	111.20	102.24	111.45	104.68	111.69
Maluku	109.40	115.50	108.16	114.74	108.27	114.89
West Java	87.00	146.40	87.55	146.67	87.94	146.38
Other Provinces	1,158.70	1,480.60	1,134.29	1,475.74	1,151.74	1,474.84
National Total	**2,867.10**	**3,340.80**	**2,836.01**	**3,315.76**	**2,822.12**	**3,315.82**

Based on the previous explanation, this study aims to identify the existing coconut supply chain in Riau, analyze quality control measures within the supply chain, and recommend improvements for quality control in the coconut supply chain.

LITERATURE REVIEW

Agricultural Supply Chain

Agricultural supply chains are characterized by the unique challenges of agricultural materials (e.g., perishability, seasonality, heterogeneity) and highly varied institutional relationships (e.g., contracts, cooperatives), with contract farming and tailored governance structures being widely studied as the most impactful mechanisms for addressing coordination and risk-sharing issues (Repar, 2017; Fu et al., 2020; Jian et al, 2023; Ho et al., 2023; Preckel, 2004)

Unique properties of agricultural materials perishability and seasonality: require specialized infrastructure (e.g., cold chains) and flexibility to prevent spoilage and manage production cycles (Fu et al., 2020; Prawitasari, 2020; Marimin et al., 2010). Heterogeneity and quality variability: variation in raw material quality complicates standardization and aggregation processes (Fu et al., 2020; Prawitasari, 2020; Profita & Kuncoro, 2022). This necessitates better quality screening and risk-adjusted governance (Profita & Kuncoro, 2022; Kuswardhani & Yulian, 2019). Geographic scattering of smallholders increases logistics complexity and necessitates aggregation mechanisms (Marimin et al., 2010; Zhong et al., 2022)

Institutional Relationships in agricultural supply chains, Contract Farming (CF) improves supply chain integration, mitigates risks for farmers and processors, and enhances product quality (Repar, 2017; Fu et al., 2020; Vermeulen et al., 2010; Anseeuw et al., 2011). Challenges: Side-selling, power asymmetries, and non-compliance undermine CF effectiveness (Repar et al., 2018; Repar, 2017). Recommendations for improvement include balanced contract models and trust-building measures (Fu et al., 2020; Ho et al., 2023). Cooperatives: enhance bargaining power, risk sharing, and collective capabilities, particularly in fragmented smallholder systems (Zhong et al., 2022). Long-term cooperative viability depends on effective benefit distribution, internal governance, and government support (Zhong et al., 2022). Informal relationships (e.g., relational contracts) supplement formal contracts in contexts with weak enforcement but are less scalable.

Risk management and integration challenges in agricultural supply chains were major supply chain risks: weather variability, price volatility, product perishability, and disease outbreaks dominate risk assessments (Profita & Kuncoro, 2022; Kuswardhani & Yulian, 2019; Marimin et al., 2010). Risk mitigation strategies: analytical tools, such as Fuzzy FMEA and ANP, are increasingly used to prioritize risks and guide planning (Profita & Kuncoro, 2022; Kuswardhani & Yulian, 2019). Digital innovations, including decision support systems and blockchain, improve traceability and enable proactive risk measures (Bacarin et al., 2008; Marimin et al., 2010). Smallholders are disproportionately affected by risks due to weak market access and limited institutional safeguards (Zhong et al., 2022).

Quality Control in the Agricultural Supply Chain

Quality control in the agricultural supply chain differs from supply chains in other areas. This is due to the characteristic, typical product, easy farming, broken, variation in biological quality of agricultural products, and is greatly influenced by conditions and environment. Some challenges in quality in the agricultural supply chain are products that are easily farm damaged and have age, keeping it short. This is why there is a need for fast handling from harvest to distribution. Fu et al. (2020), Prawitasari (2020), and Marimin et al. (2010) report a decline in quality due to delays and inadequate equipment logistics. Variations in biological product agriculture will influence its quality; besides that, in a way, it is also significantly influenced by weather, genetic diversity, and methods of agriculture (Prawitasari, 2020; Kuswardhani & Yulian, 2019). Factors that complicate the standardization of product agriculture and become obstacles to processing and distribution processes. Standardization quality (such as size, color, and taste) is difficult to achieve, due to characteristic heterogeneity from results harvest; certification organic and fair trade adds complexity in ensuring quality product agriculture in the international market (Ho et al., 2023; Kuswardhani & Yulian, 2019; Marimin et al., 2010). Diseases in plants, residue pesticides, or condition processing that is not hygienic can influence the quality of agricultural products and create control processes that become more complex (Prawitasari, 2020; Profita & Kuncoro, 2022).

Several methods and practices control quality in the agricultural supply chain, including system control field-to-fork quality, namely focusing on tracking quality in every chain in the supply chain (harvesting, storage, processing, distribution, to consumers). Tracking from "farmers" until the table eats" becomes important to ensure transparency (Bacarin et al., 2008; Marimin et al., 2010), for example, blockchain or IoT for taking notes, chain supplies, and guaranteeing food security (Marimin et al., 2010). The use of technology such as blockchain, IoT, or intelligent decision support systems can increase consistency in product quality in agriculture through supervision quality since harvesting, processing, and transportation (Bacarin et al., 2008; Marimin et al., 2010).

A contract between farmers and companies often specifies standard quality requirements, such as sugar levels for fruit or grains (Fu et al., 2020; Vermeulen et al., 2010). In some cases, the contract also includes incentives for farmers who fulfill standard quality requirements (Repar et al., 2018). The company's provision of quality inputs, such as seed varieties and fertilizer, helps ensure quality from the beginning of the supply chain (Fu et al., 2020; Ho et al., 2023). Processing post-optimal harvest in the sorting, packaging, and cooling process can ensure the quality of agricultural products (Prawitasari, 2020; Kuswardhani & Yulian, 2019). The drying method or preservation is used for materials such as coffee or grains to ensure stable distribution (Kuswardhani & Yulian, 2019; Prawitasari, 2020).

Each type of agricultural commodity requires a different approach to ensure quality. Fruits and vegetables that are highly susceptible to damage require cold storage and adequate packaging (Prawitasari, 2020; Profita & Kuncoro, 2022). The quality of coffee or grain is greatly influenced by moisture content, time processing, and engineering storage (Kuswardhani & Yulian, 2019; Prawitasari, 2020), whereas product cattle or milk requires control of microbes in hygiene processing and transportation (Fu et al, 2020; Zhong et al., 2022).

Several challenges in controlling quality products in agriculture are a lack of access to technology for farmers, limitations in infrastructure logistics in developing countries (Fu et al., 2020; Profita & Kuncoro, 2022), and the existence of different understandings among farmers, companies, and consumers about standard quality (Fu et al, 2020). Based on what was said, some control strategies for effective quality are the development of integration of digital technology that can increase transparency and traceability throughout the supply chain, so that quality can still be ensured (Bacarin et al., 2008; Marimin et al., 2010). Partnerships and training involving farmers in standardization, quality, and delivery incentives for production quality can improve overall quality outcomes (Repar, 2017; Fu et al., 2020). Improving resilience and mitigating risk, as long as the supply chain allows, by identifying risk quality earlier and more efficiently (Profita & Kuncoro, 2022; Kuswardhani & Yulian, 2019).

Coconut Supply Chain in Indonesia

The basic structure and levels of the coconut supply chain in Indonesia consist of coconut farmers, collectors, processors, industry, and exporters/international markets. Most coconuts in Indonesia are produced by smallholder farmers, who use traditional methods on a small scale. Challenges such as variable product quality and low productivity are consistently found in the literature related to agricultural supply chains, including coconut. Smallholder farmers face limited access to technology and infrastructure (Arifin, 2022; Elfahmi et al., 2024; Meilizar et al., 2024). Collectors are important actors who connect farmers with industry players (processors or exporters), but their role creates asymmetry in market power where collectors often have a higher bargaining position than farmers (Wahyudi et al., 2022; Porang et al., 2024; Elfahmi et al., 2024). This is reported to be similar to other agricultural product supply chains in Indonesia. Coconut processors (small to large scale) transform farmers' harvests into crude coconut oil (CCO) or virgin coconut oil (VCO). CCO is typically refined into Coconut Oil (CNO), which is then marketed for food and non-food applications. Further value-add ed processing is often carried out by large companies to meet international standards (Kinanda et al., 2023; Elfahmi et al., 2024). The coconut industry also utilizes waste (such as coconut shells) for alternative production such as charcoal briquettes or cocopeat (Mukhtara et al., 2015). Products such as coconut oil and coconut fiber from Indonesia are exported to countries such as the European Union, the United States, India, and the Philippines. However, export markets often require certain certifications that are difficult for smallholders to meet (Budiman et al., 2015; Simamora et al., 2016).

The coconut supply chain in Indonesia is long and complex. The upstream supply chain focuses on commodities, while the downstream supply chain is consumer-driven, emphasizing value creation with various coconut derivative products, including food and non-food items (Gunawan et al., 2020). The coconut supply chain in Indonesia is asymmetrical and largely driven by demand from the processing industry. Domestically, there is no dominant lead firm in this asymmetric supply chain to stimulate significant interest in coconut plantations. Although Indonesia's coconut supply chain has not yet reached its optimal condition, the quality of Indonesian coconuts and their derivative products remains highly competitive in the international market. Indonesian coconut charcoal, in particular, is recognized as one of the best in the world.

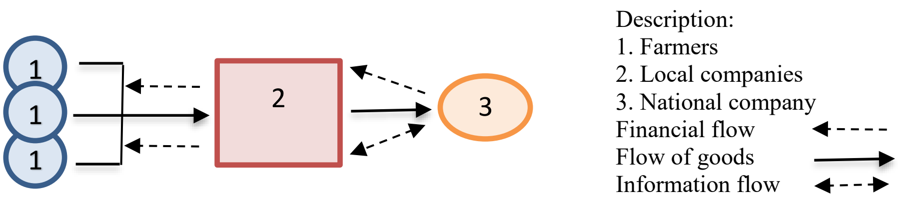
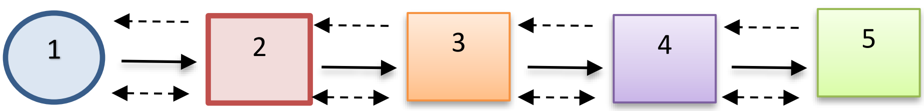


Figure 1. Supply chain pattern 1st (Suud et al., 2021)

Supply chain pattern 1st in Figure 1 shows that the coconut commodity chain begins with farmers, including partner farmers of CV Horizon, numbering over 80 individuals. The coconuts are sorted based on quality and size, depending on the intended product. Large-sized coconuts are sent directly to fulfill export orders. Medium- and small-sized coconuts are processed into white copra, while lower-quality coconuts are used to produce regular (black) copra. The financial flow involves transactions between customers, companies, and farmers. Information flow is mutual and well-integrated. Companies provide farmers with information about capacity, shipping schedules, the quantity of coconuts required, and purchase prices.



Description:

1. Farmer, 2. Trader collectors, 3. Local companies, 4. Retailers, 5. Consumers

Figure 2. Supply chain pattern 2nd (Suud et al., 2021)

In Figure 2, supply chain pattern 2nd, this supply chain pattern shows farmers sell harvested coconuts to collectors, who then distribute them to PT Saraswati in Tojo Una-Una Regency as whole coconuts. The products are subsequently distributed to shops or retailers, where they are sold to consumers as processed goods such as flour, oil, or nata de coco. The financial flow follows the sequence of consumer → retailer → PT Saraswati → collector → farmer. Consumers pay retailers for the purchased products, typically in cash. Retailers, in turn, pay PT Saraswati for the distributed products. PT Saraswati uses these funds as production capital and to purchase raw coconuts from collectors. Collectors pay farmers based on the quantity of coconuts supplied. The information flow is reciprocal, including market and purchase price updates.

Many challenges in the supply chain of coconut in Indonesia are that farmers often do not have access to modern technology, which causes productivity to be low and quality results that are not consistent (Elfahmi et al., 2024; Meilizar et al., 2024). This factor is often called in studies related to fragmented agricultural markets (Simamora et al., 2016; Wulandari and Alouw, 2021). Dependence on farmers on collectors causes prices to be low for level farmers, even though the price in the final market is high. This reflects monopsony or oligopsony patterns that often occur in chain supply in product agriculture (Wahyudi et al., 2022; Porang et al., 2024; Sanusi, 2019). Literature takes note that part of the big processing of coconut is still done in a traditional way, with constraints like a lack of cold chain facilities (cold chain) or poor quality sanitation (Taula et al., 2022; Arifin, 2022; Murtius, 2024). The coconut market is highly dependent on exports, so international price changes have a significant impact on income for small businesses. Domestic markets are also often not targeted with products that are good for absorbing products, such as VCO or briquettes (Simamora et al., 2016; Hestina et al., 2022).

METHODOLOGY

This study is descriptive and uses qualitative analysis to examine the current coconut supply chain in Indonesia. The research was conducted from June 2023 to June 2024. Data was collected from Indragiri Hilir (INHIL) Regency, Riau Province , which has the largest coconut production in Indonesia. The research location map can be seen in Figure 3. Data gathered includes the number of coconuts and logistics costs for each region; an overview of logistics transportation; coconut varieties, classification, and quality; copra classification; and its utilization in downstream industries, including crude coconut oil (CCO) as an intermediate product and refined coconut oil (CNO) as final product. Based on this overview, a Focus Group Discussion was conducted to obtain a comprehensive picture of the condition of the coconut supply chain, which was then analyzed to provide recommendations for the future coconut supply chain.

The sources of data for this study include stakeholders in the coconut supply chain, consisting of coconut farmers, copra processors, traders, the food coconut oil industry (CNO-based), the non-food coconut oil industry (CCO/CNO-based), and exporters. Data and information collected include investment, labor, energy, product types, land area, production quantities, reject rates, market share, raw material requirements and standards, and production processes. Additionally, data on information flow, financial flow, material flow, and supply chain constraints are also necessary for this study. Data on the coconut processing industry in West Java were also collected to complement the INHIL coconut supply chain.

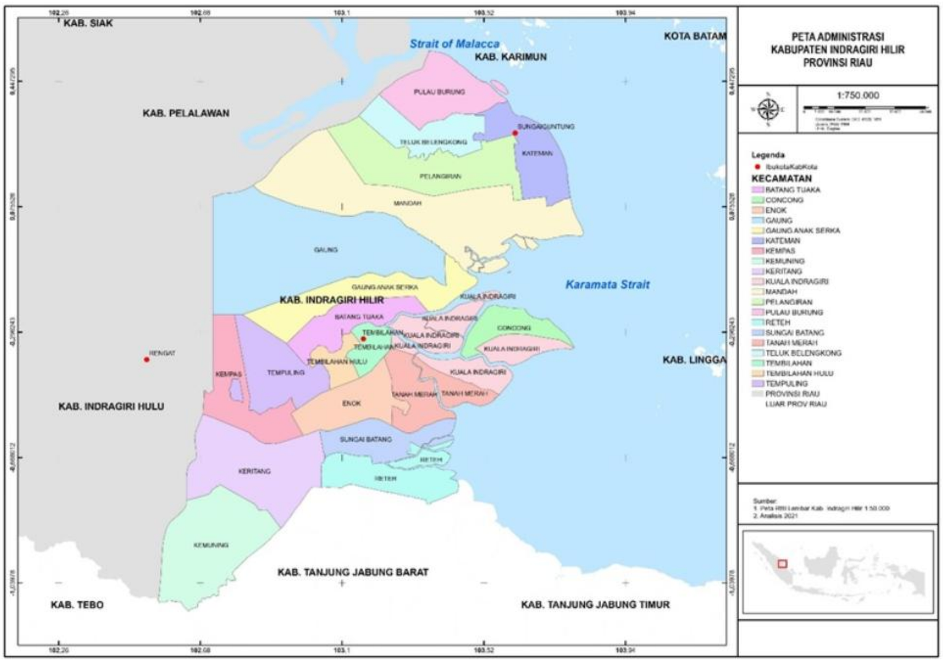


Figure 3. Reasearch location map in Indragiri Hilir (INHIL) Regency, Riau Province

The required data and information for this study were collected using the following methods: Focus Group Discussions (FGDs) were conducted to identify problems in the coconut supply chain and analyze these issues. The FGD participants included representatives from the government, associations, farmers, and business actors within the coconut supply chain. Respondents included farmers and business actors, with 47 suppliers connecting farmers to the industry; each supplier serves more than 20 farmers. Direct field observations were conducted to collect data on production, land area, and reject rates at each stage of the coconut supply chain. Based on the previous explanation, the research steps are shown in Figure 4.

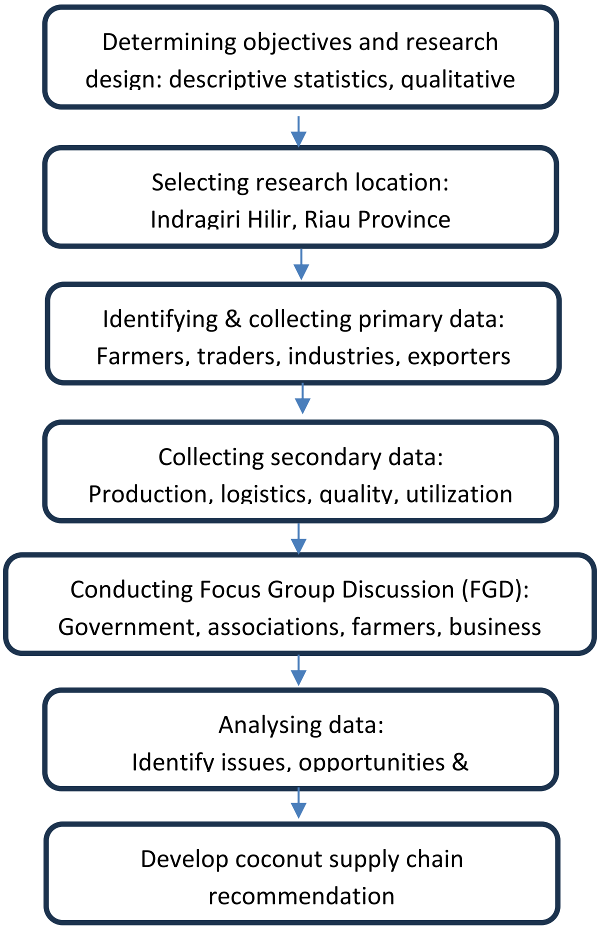


Figure 4. Research step

RESULT AND DISCUSSION

Coconut Production Quantities

The survey was conducted in Indragiri Hilir (INHIL) Regency, Riau Province, as it is the largest coconut-producing region in Indonesia. Coconut production in each province of Indonesia is presented in Table 1. Riau Province is the leading producer of coconuts in Indonesia. Of the 12 districts in Riau Province, Indragiri Hilir contributes the highest production, accounting for 72.9% of the total.

Survey results of coconut production and quality in Indragiri Hilir Regency, collected from 47 coconut collectors, show a total standard coconut capacity of 2,735 tons per day (excluding coir) or 1,289,357 tons per year (whole coconuts). Non-standard coconut amounts to 1,116 tons per day or 368,280 tons per year. Based on this data, non-standard coconuts account for approximately 30% of total production. Figure 5 illustrates the distribution of coconuts among collectors in Indragiri Hilir (INHIL) Regency.

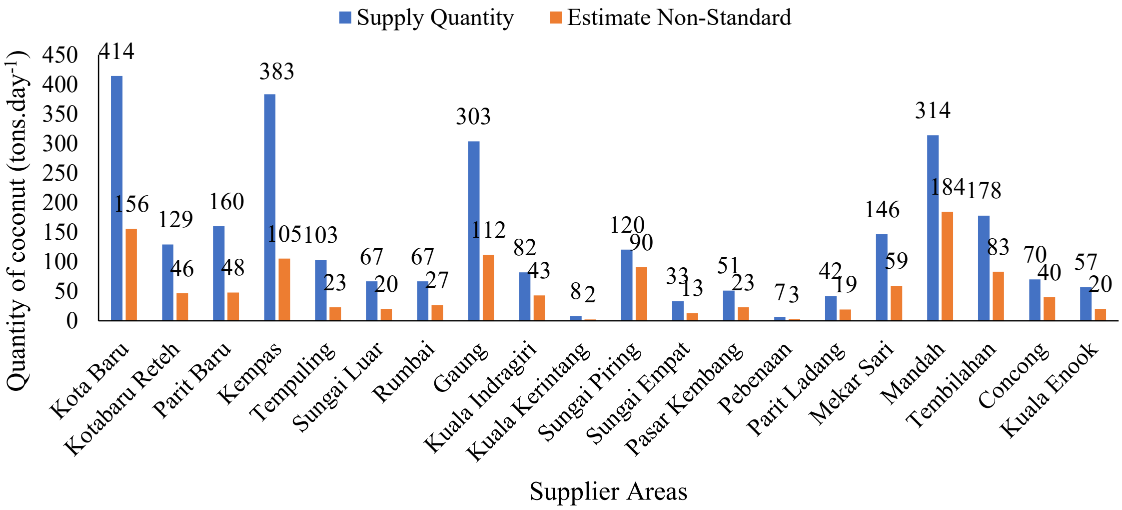


Figure 5. Distribution of coconut quantities among collectors in Indragiri Hilir, Riau

Logistics costs for coconuts in Indragiri Hilir Regency per year are depicted in Figure 6. In addition to land transportation, the majority of coconut transportation utilizes river routes, as shown in Figure 7.

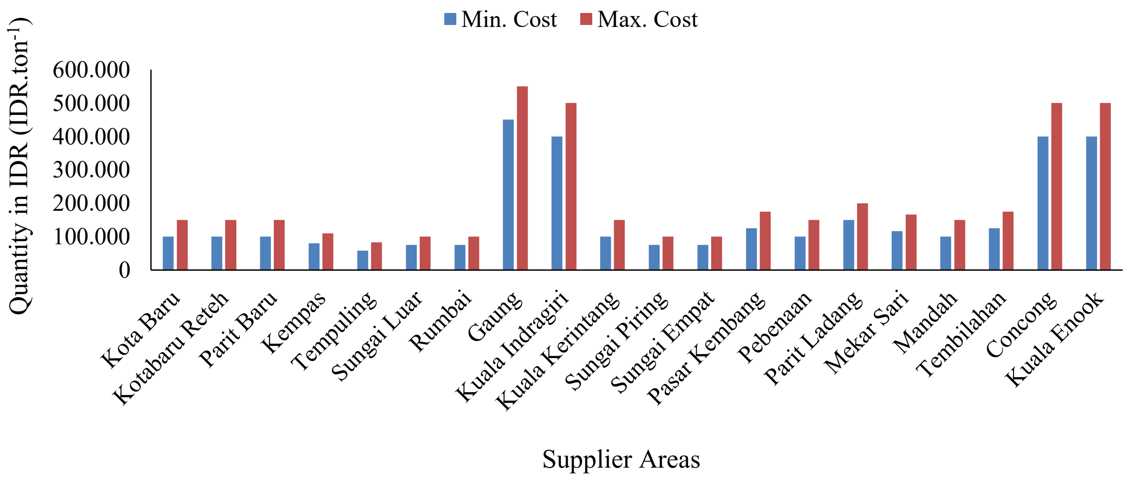


Figure 6. Costs logistics coconut in each region (Cost IDR 186,625.ton^{-1}.kg^{-1})

Figure 7. Coconut transportation logistics in Indragiri Hilir Regency

Based on data collected in Indragiri Hilir, Riau Province, approximately 20-30% of coconuts are classified as "non-standard" during sorting at the farmer or collector level. At the processing factory level, about 30% of coconuts are also categorized as non-standard. Standard-grade coconuts are processed into various products such as coconut milk, coconut flour, and coconut water. Additionally, coir and coconut shells are processed into products such as briquettes and coconut shell charcoal. Over 90% of coconut fiber is discarded as waste, with less than 10% processed and sold as coco fiber and coco peat. Utilizing coconut coir for biomass or other purposes could significantly reduce overall production costs. Currently, a small portion of coconut fiber is used for drying copra.

Standard-grade coconuts are further processed into copra, which serves as the raw material for crude coconut oil (CCO) and virgin coconut oil (VCO). Refined coconut oil is used as a raw material in the food industry (32%), with the remainder used in the non-food industry. This supply chain flow is illustrated in Figure 8.

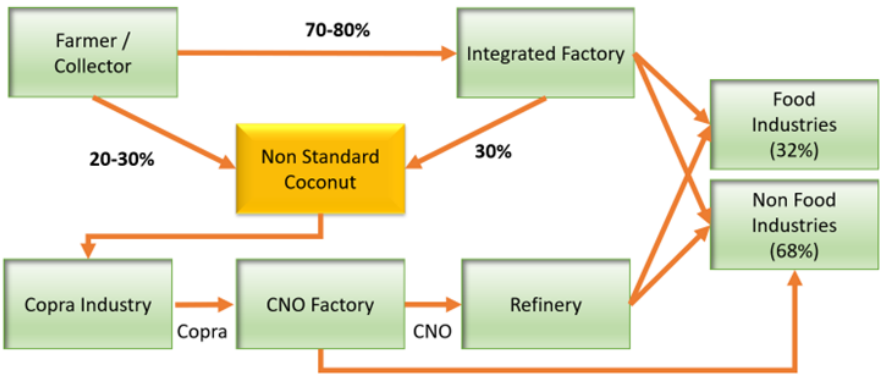


Figure 8. Standard coconut supply chain

Coconut Type

Coconut is classified into three main types: tall coconut, dwarf coconut ("genjah"), and hybrid coconut. The characteristics of these three types of coconuts are outlined in Table 3. Tall coconut is superior in terms of its longer lifespan, larger fruit, and thicker coconut meat, resulting in higher copra production than the other two types. However, its disadvantage is its taller plant height and longer maturation period, as it only starts bearing fruit after 6-8 years, unlike other types. The superior traits of tall and dwarf coconuts are expected to be combined in hybrid coconuts, as detailed in Table 3.

Table 3. Characteristics of each type of coconut

Stakeholders	Tall coconut	Dwarf coconut	Hybrid coconut
Fruiting	6-8 years	3-4 years	4-6 years
Plant heigh	15-30 m	5-7 m	3-6 m
Nut weight	1.5-2.5 $kg.nuts^{-1}$	0.85 $kg.nuts^{-1}$	1 $kg.nuts^{-1}$
Number of fruits	90 $nuts.tree^{-1}$	140 $nuts.tree^{-1}$	135-160 $nuts.tree^{-1}$
Productive age	80-90 years	40-50 years	60 years
Copra content	176 $g.nut^{-1}$	92 $g.nut^{-1}$	135 $g.nut^{-1}$
Oil content of dry copra		60-70%	
Water content of dry copra		5-10%	

Coconut Classification

After harvesting, coconuts are transported by farmers to collectors through two methods: pre-sorted or unsorted (commonly referred to as "ramas"). Coconut collectors then sort the coconuts into standard and non-standard categories. The criteria for standard and non-standard coconuts are presented in Table 4. Standard coconuts must weigh ≥ 0.6 kg, have a diameter of ≥15 cm, and be harvested between 3-12 months of age. They should also be intact and without visible sprouts. Coconuts are classified based on size and weight into categories A, B, C, D, and boncos/small. Coconut A weighs 1.4 kg, coconut B weighs 0.9 kg, coconut C weighs 0.6-0.7 kg, coconut D weighs 0.4 kg, and “boncos”/small coconuts weigh 0.2 kg.

Table 4. Criteria for standard and non-standard coconuts

Criteria	Standard Coconut		Non Standard Coconut	
Size		Weight≥0.6 kg Diameter≥ 5 cm		Weight< 0.6 kg Diameter<15 cm
Harvest age		3-12 month		Too old > 12 month
				Young < 3 month
wholeness		Whole		Broken
Germination		No buds		Grow shoots

Copra Classification

Coconuts that do not meet the standard criteria are processed into copra. The quality of copra depends on the processing method and raw materials used. Copra processing methods include white copra (dried in the sun) and black copra (dried over smoke). Processed copra is categorized into edible, regular, and rejected copra. Most edible and regular copra is exported, while rejected copra is marketed locally. The differences among the three classifications are shown in Figure 9.

a)

b)

c)

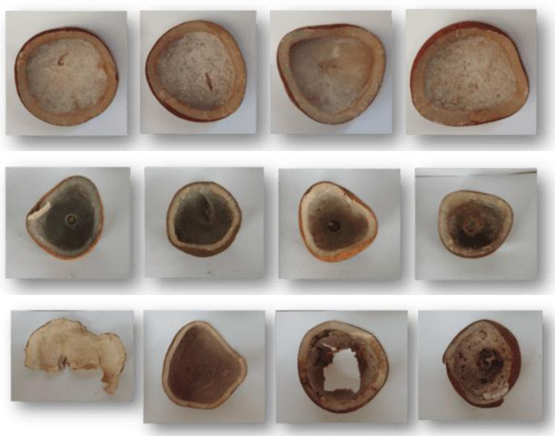


Figure 9. Classification of copra
a) Edible copra, b) Regular copra, c) Rejected copra

The prices per kilogram are: edible copra, IDR 12,500; regular copra, IDR 8,200; and rejected copra, IDR 7,400. The quantity of copra produced depends on the coconut type. Tall coconuts yield 15% edible copra, 60% regular copra, and 25% rejected copra, while hybrid coconuts yield 40% edible copra, 40% regular copra, and 20% rejected copra. Coconuts can be processed into crude coconut oil (CCO) and coconut oil through physical and chemical extraction processes. Physical extraction can be performed using wet or dry methods. The main difference lies in the raw materials: dry extraction uses copra, while wet extraction uses fresh coconuts. Wet extraction methods include salting, pickling, fishing, and enzymatic techniques.

Copra processing in one of the CNO industries in West Java: The copra, sourced 90% from Sumatra and 10% from Banten, is stored in a warehouse before being processed in the production facility. With a monthly capacity of 500 tons of copra, this factory produces 275 tons (55%) of CNO and 150 tons (35%) of animal feed. The animal feed is derived from copra residue after extraction.

In Figure 8, the process of producing CCO at a coconut processing factory in Subang, West Java, is illustrated. The process begins with crushing using Hammer Mill 1 and Hammer Mill 2. Next, the mixture is heated to 80°C-90°C. Oil is then separated from the copra residue by filtration. The final stage is a purification process to separate oil from water.

Coconut Supply Chain

Based on observations of coconut plantations in Indragiri Hilir, approximately 15.818 million kilograms of coconuts are produced annually from 351,526 hectares of coconut plantations in the region. With an average of 30-40% classified as non-standard coconuts, an estimated 188 million kilograms of copra can be produced per year. Edible and regular copra are typically exported, accounting for 75-80% of total production, while the remaining portion consists of rejected copra. The copra is processed into Crude Coconut Oil (CNO) or raw coconut oil, which is subsequently used in the food industry (68%) and non-food industries (32%). The current coconut supply chain is illustrated in Figure 10.

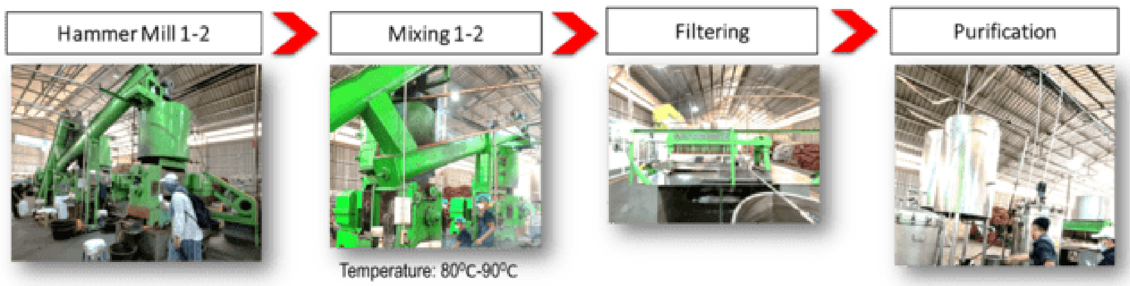


Figure 10. Coconut Processing into CCO in Subang, West Java

Coconut Supply Chain Recommendations

The added value of coconuts can be enhanced through processing that extends into downstream industries. Sustainable Aviation Fuel (SAF) represents an alternative downstream coconut product with significant potential to increase value. The International Civil Aviation Organization (ICAO) has established SAF as a mandatory alternative fuel for all international flights. Coconut oil is a highly suitable raw material for SAF production due to its higher C-12, C-14, and C-16 hydrocarbon content compared to other vegetable oils.

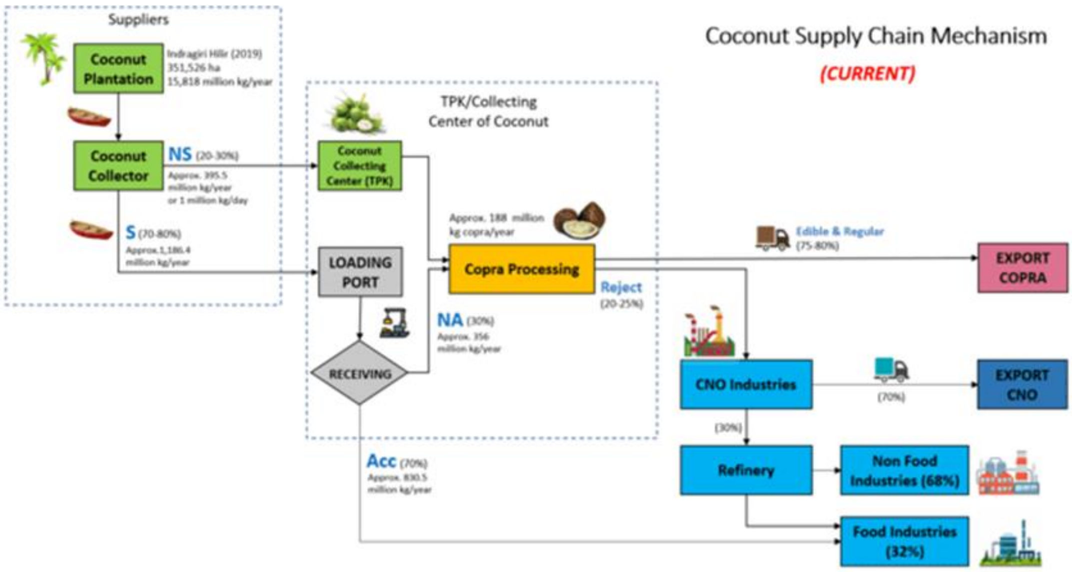


Figure 11. Current coconut supply chain in Riau Province

According to Rais (2021), based on market-based mechanisms developed under ICAO, airlines that are members of the International Air Transport Association (IATA), along with the broader aviation industry, have collectively committed to reducing emissions. SAF plays a pivotal role in achieving these goals. Several countries have set targets for SAF usage in aviation by 2030, including Finland (30%), France (5%), Germany (2%), the Netherlands (14%), Norway (30%), and Sweden (30%).

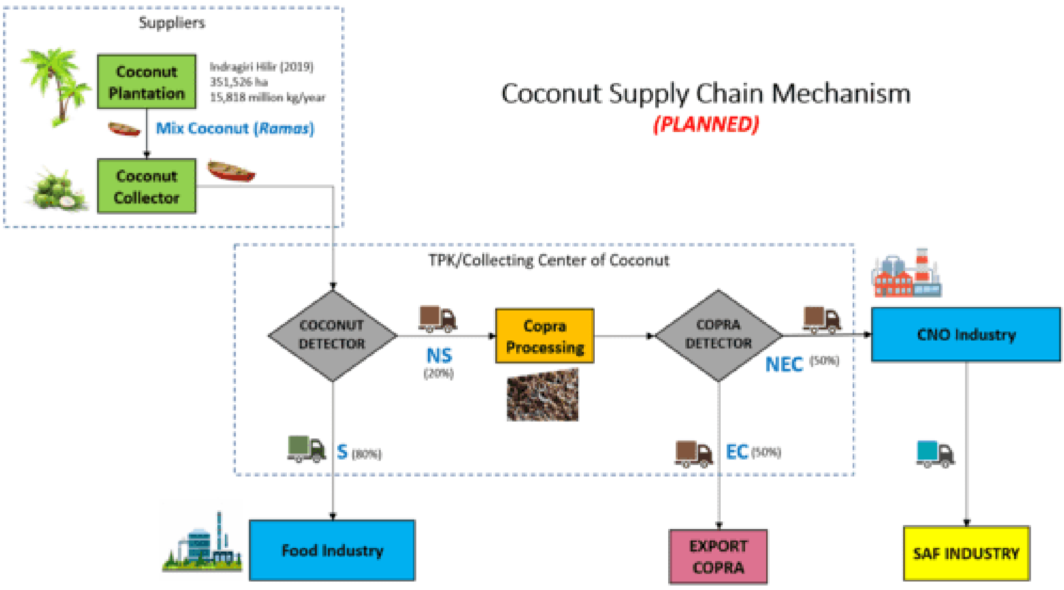


Figure 12. Proposed coconut supply chain

The utilization of non-standard coconuts as a raw material for SAF production is expected to meet global SAF demand without disrupting the food industry's coconut-based supply chain. To achieve this, an effective system for sourcing non-standard coconuts must be implemented to align the supply chain with production plans while ensuring a steady supply for the food industry.

One solution involves employing a tracking system to monitor coconut quality from farmers, collectors, and copra processing industries through to downstream food and non-food industries. The current coconut supply chain (Figure 11) and the proposed supply chain with integrated product quality tracking (Figure 12) are depicted.

CONCLUSIONS

Based on the conducted research, the following conclusions can be drawn that the coconut supply chain in Riau begins with coconut farmers and collectors, followed by the copra industry (30%) or coconut processing industry (70%), then the CNO industry, and finally, the food industry (38%) or non-food industries. Quality control in the coconut supply chain includes: 1) Sorting standard and non-standard coconuts at the farmer or collector level, 2) Classifying copra at the industrial level into edible copra (15%), regular copra (60%), and rejected copra (25%). Quality control in the coconut supply chain includes: 1) Sorting standard and non-standard coconuts at the farmer or collector level, 2) Classifying copra at the industrial level into edible copra (15%), regular copra (60%), and rejected copra (25%), and 3) Enhancing the added value of non-standard coconuts by converting them into downstream products, such as Sustainable Aviation Fuel (SAF).

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