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(REVIEW ARTICLE)

Agro-industrial development and valorization of coconut fruit waste In Indonesia: A review

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Abstract

The development of coconut agro-industry in Indonesia has the potential to be carried out, one of which is by valorizing waste / by-products of product processing, especially coconut fruit. Indonesia as the highest coconut producing country in the world, has abundant resources and has not been optimally utilized. This review discusses systematically from various sources of national and or international research articles to discuss the development of coconut agro-industry in Indonesia. Coconut plantations in Indonesia are divided into 3 forms, 98% are smallholder plantations. So that efforts to develop coconut agro-industry and including valorization of its waste will potentially improve the economy of the community.

Keywords: Development; Agro-industry; Coconut waste; Valorization

1. Introduction

Indonesia is one of the largest producers of coconut (*Cocos nucifera* L.) in the world based on 2016-2020 data [1], followed by India and Philippines [2], with an area of around 3.7 million Ha [3]. Three types of coconut plantation management exist in Indonesia, based on plantation statistics for 2020–2022. Large state plantations, which occupy 3,934 Ha, large private plantations, which occupy 14,650 Ha, and smallholder plantations, which occupy 3,343,556 Ha, roughly correspond to 98% of them [4]. The area of coconut plantations by province in Indonesia was reported by the Directorate General of Plantations for the years 2017–2021. The data reveals that there are 34 provinces in Indonesia with coconut plantations, with Riau having the largest plantation, followed by North Sulawesi, East Java, Central Sulawesi, and North Maluku [2].

Indonesia is also a coconut exporting country [5] and its derivative products with export destination countries including Malaysia, China, India, the Netherlands, Korea and Japan. Indonesia's coconut exports until the quarter of 2020 were recorded at 988.3 thousand tons or USD 519.2 million. While the number of exports of Indonesian coconut derivative products is still relatively low, in 2019 it reached USD 2.17 billion, consisting of processed coconut meat of IDR 663.8 million tons, coconut shells of IDR 209.6 million, coconut water of IDR 35.3 million, and coconut fiber of USD 12.6 million [6].

The coconut plant is said to be the plant of life because of the benefits and multipurpose of all parts of the plant. Coconut plants are also very close to the hearts of Indonesian people [7], coconut oil has been traded for a long time, imports of coconut oil from Asia to Europe have been carried out starting in the 17th century [8]. Starting from the stem, leaves, sticks, parts of the fruit can be processed into various products. Coconut fruit can not only be processed into coconut milk, copra and coconut oil (coconut oil and Virgin Coconut Oil), but also coconut water, coconut coir fiber to coconut shells can be processed. So that coconut plants have a strategic value that plays an important role economically, socially and culturally in Indonesian society [9].

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The coconut processing industry is not well developed in Indonesia. The coconut industry has not been seen to have a significant economic impact on society, one of which is seen in terms of industrial management which is still mostly carried out at the farm level with low management [10]. In addition to this [11] revealed that Indonesian coconut exports are generally in the form of primary products, while the derivatives are only a small part.

Efforts that can be made to develop coconut derivative products are efforts to process natural resources, processing with technological support in an industry to produce various products that provide higher economic value (added value), the business is known as agro-industry. The added value of commodities due to treatment such as processing given to commodities will have an impact on economic value [9]. Coconut processing into several derivative products, including: coconut water processing into various products (nata de coco, candy, syrup), shell processing into charcoal, briquettes, crafts, coconut coir processing into various forms of products such as ropes, carpets, car seats, chairs or textile [10]. Agricultural countries are competing to develop agro-industry through their specialized natural resources. The goal is the welfare impact on their people. For example, Thailand developed a food agro-industry and is now considered the world's largest dynamic and diverse agro-industry [1] [12].

The development of coconut agro-industry into derivative products, of course, is through the role of various stakeholders and related organizations. Agro-industry processing is considered a powerful business idea to increase the added value of coconut while supporting the empowerment of farming communities. This paper will review the development of agro-industry.

2. Methods

The main methodology of writing this review article is analyzed from various literature with a systematic review. A structured review system and search for relevant national and international journals to determine the theories and topics to be discussed in the review article.

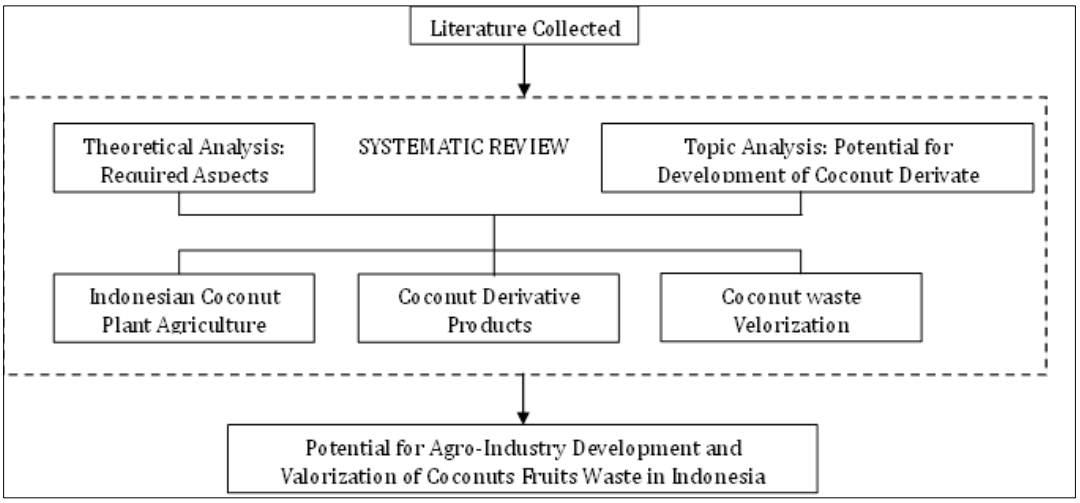

Figure 1 Systematic Review Process

2.1. Data collection

Data collection was carried out by exploring international journals from several databases, including: Pubmed, Google Scholar, Semantic Scholar and Science Direct on Harzing's Publish or Perris software. Provisions related to the potential and development of coconut-derived product agro-industry in Indonesia, focused on the valorization of coconut fruit waste.

The main topic is to analyze literature reviews or national and international articles on coconut agro-industry in Indonesia. Relating to the potential development of coconut derivative products and value added from the utilization of coconut fruit waste. The setting is to determine the topic and title of the abstract keywords from review articles and research journals in the academic research database.

2.2. Data Analysis

By searching the total results of review articles and national and international journal research on potential traceability and agro-industry development of coconut derivative products and value added from coconut fruit waste in Indonesia became the main topic in this review. The systematic review process is shown in Figure 1.

3. Indonesian Coconut Plant

Coconut (*Cocos nucifera* L.) is one of the world's most recognized plantation crops. As a plant that has many benefits, all parts of the coconut can be processed into products that have high economic value [13]. Coconut is taxonomically the only species belonging to the genus Cocos with two varieties: tall (var.typica) and dwarf (var.nana). Based on its color form, this dwarf variety germplasm can be divided into three sub-varieties, namely dwarf green, dwarf red, and dwarf yellow. Furthermore, red dwarf can be divided into two different phenotype, namely Malay and Cameroon [6]. 20% of Indonesian coconut germplasm has been collected, mostly from wet climate dry lands [14].

The province with the largest coconut plantation in Indonesia is Riau. Riau is one of the richest provinces in Indonesia due to its various natural resources, including coconut. Indragiri Hilir is one of the districts that has the largest coconut plantation area in Riau. Statistical data shows that the coconut area in Indragiri Hilir is 440,821 ha [13], equivalent to 12% of Indonesia's coconut plantation area [15]. 86% of the total peat-land area in Indragiri Hilir is planted with coconut. Coconut has also been an important commodity for local communities since the late 1800s [7]. The coconut variety that can grow on the tidal land of Indragiri Hilir is Sri Gemilang, with a productivity of 3.0 tons of copra/ per /year [16].

South Kalimantan has a local coconut cultivar with unique characteristics, the Genjah Salak. Generally, this coconut is characterized by small fruit, a slender trunk, relatively short leaves, fast flowering, and mostly self-pollinating. Plants can flower at 1.5 years of age and initially harvest for three years. Fruit production per stem can reach 80–120 fruits per tree per year [6].

Research conducted on Babasal inner coconut in Banggai Regency, Central Sulawesi Province, has a high productivity of 3.2 tons copra/ha/year, 61.09% copra oil content, 8.13% protein content, and specific characteristics, namely the number of fruits per bunch > 10 grains, high pulp oil content [17]. Another coconut variety found in Central Sulawesi is buol coconut. Profound productivity > 3 tonnes of copra/ha/year a 61% copra oil content, and distinct traits rapid fruiting ± 40 months slow stem growth, and a Bole on the trunk [18].

High-variety coconut as a local cultivar of Gorontalo. Research results show that Gorontalo high local coconut has two cultivars with high productivity, namely Molowahu inner coconut (DMU) and Kramat inner coconut (DKT). Both cultivars show high productivity (above 3 tons of copra/ha/year) and have a high oil content (above 64%) [19].

Aceh Province has Lampanah tall coconut. The morphology of Lampanah tall coconut consisting of leaf crown, stem, flower and fruit is generally quite uniform, the polar circumference is generally larger than the equatorial circumference, the fruit shape is classified as round, egg-shaped and elliptical, the seeds are generally round. The number of bunches is 13.35 fruits/tree and the number of fruits is 9.25 fruits/bunch or an average of 138 fruits/tree/year. Lampanah tall coconut has a fresh meat weight of 449 g/seed or about 224 g copra/seed and copra production potential is 30.97 kg/sawit/year or 3.80ton copra/ha/year. Fat content is 66.40%, copra water content is about 3.42% and protein is about 6.81%, total saturated fatty acids are 94.27%, medium chain saturated fatty acids are 67.21% and lauric acid content is 46.50% 50% [20].

Puan Kalianda coconut variety originating from South Lampung, is a newly released high kopyor coconut from Kalianda, South Lampung, Indonesia. Kopyor coconut is a mutant coconut of high economic value with abnormal endosperm [21]. Activities carried out in Sikka Regency, Flores Island, Sikka Deep Coconut (DSK) has a coconut production of 2.5ton copra/ha/year [14].

Kopyor coconut is a unique type of coconut, compared to other coconuts, this type of coconut has better economic value. Kopyor coconut is widely used to mix drinks such as ice kopyor and ice cream because its esdosperm is delicious. Kopyor coconut is often found in Central Java (Pati), East Java (Sumenep) and Lampung (Kalianda), growing in limited populations and/or singly [22].

Mastutin coconut variety found in Sumbawa, West Nusa Tenggara. Mastutin coconut is capable of producing > 3 tons of copra/ha/year. Mastutin coconut oil content is 61.88%. It grows well in areas that experience 4 – 6 months of drought, and has the characteristic of a large stem circumference [23].

4. Coconut Agro-Industry Development in Indonesia

Coconut development in Indonesia has been extensively researched, starting from the cultivation system with smallholder coconut rejuvenation related to seed system development, capacity building of farmers and farmer organizations, and technology support [24]. Control of fungi that cause fruit drop [25] and pests that reduce coconut productivity [26]. Selection of superior seeds and varieties in Central Sulawesi [17]. The coconut management and development strategy are with the development pattern of BUMD and BUMDes through development programs through the relevant OPD, as well as establishing cooperation with companies both local and outside the region in the short term and exports for the long term [15]. Other research examines the development of coconut agribusiness in Rokan Hilir [27] and in Indragiri Hilir Riau, among its weaknesses: (1) farmers have not been able to adopt most of the technology, and (2) lack of diversification of coconut products. Therefore, several strategies are suggested: (1) efforts to increase market absorption can be done with diversification, (2) efforts to promote marketing programs in the world market, with government assistance, and (3) empower farmers such as farmer group cooperatives [28].

Another coconut development effort proposed based on research is integrated product development [29]. Integrated coconut agro-industry development in this case is not limited to one industry that produces all processed coconut products but involves different industries for each processed coconut product. Each industry can support each other in providing raw materials [13]. In coconut agro-industry, derivative products can be grouped into several groups such as in the form of foodstuffs in the form of coconut oil (VCO and also coconut oil), nata de coco, coconut pulp flour, non-food products in the form of crafts, animal feed, charcoal, briquettes, charcoal, organic fertilizer, biodiesel, and so on [29]. Improvements in production and processing of coconut-derived products have also been carried out, including processing coconut into VCO with a centrifugal system, the results of the study showed that the centrifugal system produced a higher yield of 5-6 liters and quality properties (water content, free fatty acids, peroxide numbers), better organoleptic properties and quality meeting the requirements of the Indonesian National Standard (SNI) [30]. VCO is an oil obtained from coconut meat with many benefits and clear white color [31].

Table 1 Feasibility Analysis of Some Coconut Derivative Products

No	Coconut Commodity Processed Product Alternatives	The Value of the Decision
1	Coconut oil	High (H)
2	Coconut milk	High (H)
3	Coconut sugar	High (H)
4	Nata de Coco	High (H)
5	Handicraft Industry	Medium (M)
6	Copra	High (H)
7	VCO	Medium (M)
8	Coconut Fiber	Medium (M0
9	Desiccated Coconut	Medium (M)
10	Charcoal	High (H)

Cooking oil, margarine and white butter, soap raw materials and cosmetic formulations can be derived from coconut oil. Galang District, Deli Serdang Regency is one of the coconut oil producing areas in Indonesia but still on a small scale. Based on research that has been conducted, there is an increase in the cost of goods and variable costs before the addition of equipment with after from Rp. 41,746/L and variable costs are Rp. 39,236/L. to Rp. 104,211/L and the calculation of variable costs is Rp. 89,757/L [32]. Coconut oil can also be developed into derivatives to protect against fluctuating coconut oil prices. The derivative products in question are in the form of oleo-chemicals (fatty acids, fatty acid methyl esters, fatty acid alcohols and glycerine) [33].

Expert aggregation in research that has been conducted in Indragiri Hilir from 10 products that are tested for development and have potential, there are six processed products with a decision value of "High" (H), which is a high value. The six products include coconut oil, coconut milk, coconut sugar, nata de coco, copra, and charcoal. Of the six products, coconut oil, coconut milk, and copra are produced from the same raw material, namely coconut meat. While coconut sugar is "nira" (sap), nata de coco from coconut water, and charcoal from other parts of the coconut plant, namely the shell. Results are presented in Table 1 [13].

Copra is one of the products derived from dried coconut meat. According to the research that has been conducted, the income obtained from the white copra processing business with the greenhouse system by three respondents in North Buton averaged Rp. 20,146,611. Overall, the average feasibility value of the three respondents was 1.3. Because the feasibility results obtained are > 1, it means that the business is feasible [34]. Copra is also one of the products that improves the welfare of farmers and development in Minahasa [35].

The famous centre of coconut sugar production in Indonesia is Banyumas Regency. Based on research that has been conducted, the coconut sugar industry at the rural farmer level in Banyumas Regency is an industry that has been carried out for generations, with processing or production technology still traditional. In this district, there is a unique coconut sugar management model. Symbiotic mutualism between processors and coconut/garden owners and also stalls/collectors with price transparency. Efforts are made to expand into the international market with internet access and the formation of groups or cooperatives [36]. Coconut sugar has health benefits due to its low GI [3].

5. Potential Derivative Products from Coconut Fruit Waste

By-products that can be produced from materials that are considered waste, actually have potential economic importance, such as nutritious coconut water, coconut shells and coconut fibre. This can be realized with product diversification by expanding its economic spectrum [37].

5.1. Coconut Coir

Coir is the skin of the coconut fruit that has not been optimally utilized. Farmers or the coconut processing industry create coir as a byproduct. Many coconut farmers burn or discard coconut husks, resulting in piles of solid and liquid waste that create odour and pollute the environment. On average, every 8 coconuts can produce 1 kg of coconut husk. If the production of coconut fruit in Indonesia is 15 billion grains, then the total production of coconut fibre is 1.875 billion kg, or about 1.875 million tons of coconut fibre per year. From the above data, there is a potential for coconut fibre to be used as products that have enormous value-added value. These products include hardboard, paper materials and textiles. Coconut fibre enters the world trade as coir fibre. The actors in the coconut fibre supply chain of the processing industry consist of coconut producing farmers, collectors, the coconut fruit processing industry, and the coconut fibre processing industry [9].

Coir is an agricultural waste that often accumulates on the roadside of Banda Aceh without further processing. Coir is the thick and fibrous part that coats the coconut fruit [38]. Increasing the creative economy by utilizing coconut fibre as a natural resource that is considered waste can improve the economy of farmers and local residents. This activity utilizes waste to create environmentally friendly products in the form of processed handicrafts [39]. Another handicraft that can be made from coconut fibre is the form of puppets [40].

5.2. Coconut Water

Coconut water as a beverage is rich in benefits, not only functional but also nutraceutical, used as isotonic or re-hydrating [41]. Coconut water is one part of the coconut fruit that can be processed into various derivative products, such as nata de coco, candy, syrup and soy sauce. The calculation of the added value that has been carried out on coconut water derivative products using the Hayami method shows that the highest added value is obtained from candy at Rp. 69,980.8/kg; while the lowest added value is recorded from nata de coco at Rp. 960.52/kg [1]

5.3. Coconut Shell

One of the coconut shell processes is activated charcoal. Activated charcoal has a variety of applications in the adsorption process. The stages of making active charcoal begin with preparation, carbonation and activation of charcoal into active charcoal using the addition of steam as an activator [42]. Coconut shells can also be pulverized into powder with a size of 0.250 mm and combined with palm fibre to produce composites [43]. In addition, bio-coconut charcoal is also one of the coconut shell diversity products; this product is more environmentally friendly and cleaner [44].

6. Conclusion

The development of coconut in Indonesia is very potential to be developed, given the abundant resources (spread throughout the regions in Indonesia). Coconut development in Indonesia has not been optimized, both in terms of cultivation, maintenance and efforts to increase productivity. However, there has been a lot of research and government efforts made for this. For example, research on the selection of superior seeds, proper maintenance efforts to product diversification. The potential for product development and including waste valorization is also very large, because one of the agro-industry development efforts is to increase the economic value of the by-products produced.

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