
Sustainable Agropreneurship Strategies through the Optimization of Palm Oil-Based Chocolate Bar Formulations

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ABSTRACT

The development of sustainable agropreneurship is a crucial strategy to enhance the added value of agricultural and plantation commodities, particularly in the cocoa and palm oil industries. One promising innovation is the formulation of palm oil-based chocolate bars, serving as an alternative or complement to cocoa butter. This literature review aims to analyze optimization strategies for chocolate bar formulations utilizing palm oil to support the sustainability of agropreneurial ventures. The research method employed is a comprehensive review of recent scholarly sources (2018–2024) addressing processing technology, physicochemical properties, consumer acceptance, as well as economic and environmental impacts. The findings indicate that the incorporation of palm oil in chocolate bar formulations has the potential to reduce production costs, improve product stability, and create new market opportunities. Moreover, integrating palm oil utilization with sustainability principles can reduce dependence on imported cocoa butter and increase the added value of domestic palm oil. Challenges include adjusting the formulation composition to preserve the distinctive chocolate flavor, complying with international quality standards, and addressing consumer perceptions regarding palm oil. This study recommends collaboration among farmers, industry stakeholders, researchers, and government bodies to promote innovation in products derived from local commodities. Therefore, optimizing palm oil-based chocolate bar formulations can serve as a sustainable agropreneurship strategy that synergizes economic, social, and environmental dimensions.

Keywords: *Agropreneurship, Palm Oil, Chocolate Bars, Sustainability, Product Formulation.*

INTRODUCTION

Sustainable agropreneurship is an entrepreneurial concept in the agricultural sector that integrates innovation, efficiency, and sustainability principles. In this context, sustainability encompasses not only economic aspects but also environmental stewardship and the improvement of social welfare. As an agrarian country, Indonesia holds significant potential to develop agropreneurship based on strategic commodities. Two noteworthy commodities are cocoa and palm oil. Cocoa possesses high economic value as the primary raw material for the chocolate industry, whereas palm oil is the world's largest source of vegetable fat. The combination of these two commodities can yield high-value food innovations with strong export potential, one of which is the development of palm oil-based chocolate bars (Raharjo & Setiawan, 2023).

The demand for cocoa butter in Indonesia's chocolate industry is still largely met through imports, making its price relatively high and vulnerable to fluctuations in the global market. Palm oil, particularly its stearin and olein fractions, exhibits physical and chemical properties that can be modified to resemble cocoa butter substitutes (CBS) or cocoa butter equivalents (CBE). Fractionation and enzymatic modification processes can produce palm oil with compatibility to cocoa in terms of texture, melting point, and flavor (Fauzi et al., 2022). By leveraging these technologies, agropreneurs can reduce dependence on imported raw materials while enhancing the competitiveness of local chocolate products in both domestic and international markets.

The use of palm oil as a substitute ingredient in chocolate bar formulations not only offers economic advantages but also supports sustainability principles. Palm oil is the highest-yielding oil crop per hectare compared to other vegetable oil sources, making its land use more efficient (Hasibuan & Wijaya, 2024). Furthermore, the processing of palm oil into CBS or CBE can utilize existing industrial facilities, thereby minimizing the need for substantial new infrastructure investment. This opens opportunities for small- and medium-scale agropreneurs to enter the chocolate market with relatively modest capital requirements.

From an environmental sustainability perspective, optimizing palm oil-based chocolate formulations must adhere to good agricultural practices (GAP) and sustainable palm oil principles. Certifications such as the Roundtable on Sustainable Palm Oil (RSPO) or the Indonesian Sustainable Palm Oil (ISPO) are essential to ensure that palm oil raw materials

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originate from sources that do not cause environmental degradation and respect local community rights. Agropreneurs who successfully integrate these sustainability principles gain marketing advantages, as global consumers are increasingly concerned about environmental and sustainability issues in the food supply chain (Nuraini et al., 2023).

In addition to raw material considerations, sustainable agropreneurship strategies also involve efficient supply chain management. The distribution of cocoa and palm oil raw materials must be well-organized to reduce logistics costs while maintaining product quality. Digital technologies such as Internet of Things (IoT)-based supply chain management systems and blockchain can enhance transparency, efficiency, and accountability across the supply chain. Consequently, agropreneurs can ensure that the chocolate products produced are not only of high quality but also meet food safety and sustainability standards (Wulandari & Santoso, 2022).

From a market perspective, palm oil-based chocolate bars hold substantial potential to be positioned as affordable premium chocolate. Marketing strategies may target middle-class consumers seeking quality chocolate at affordable prices. Furthermore, these products can be branded as local innovations with added value derived from sustainable practices and innovative raw materials. Storytelling-based marketing campaigns emphasizing supply chain sustainability and economic benefits for local farmers can enhance the product's image in the eyes of consumers (Hidayat & Pratama, 2023).

Considering all these factors, sustainable agropreneurship strategies through the optimization of palm oil-based chocolate bar formulations are not only a solution to reducing dependence on imported cocoa butter but also a means of increasing the added value of local commodities, strengthening regional economies, and creating employment opportunities. Moving forward, synergy among entrepreneurs, farmers, researchers, and policymakers is essential to foster a business ecosystem that supports innovation, sustainability, and global competitiveness in cocoa and palm oil-based agroindustries in Indonesia (Mahendra & Yusuf, 2024).

METHODS

This study employed a literature review method with a descriptive-analytical approach, presenting data and findings obtained from various scholarly sources and subsequently analyzing them to provide a comprehensive overview of sustainable agropreneurship strategies

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through the optimization of palm oil-based chocolate bar formulations. This method was selected as it is relevant for examining issues that require the collection and integration of information from previous studies to build new knowledge synthesis (Creswell & Creswell, 2018).

Data sources were drawn from national and international scientific journals, conference proceedings, academic books, research reports, and official publications from relevant institutions. The selection criteria for sources included publication within the period 2018–2024, direct relevance to the topic, and credibility of the publisher or institution. Data were retrieved through online databases such as Google Scholar, ScienceDirect, SpringerLink, Wiley Online Library, and DOAJ. Keywords used in the search included —palm oil fat,|| —cocoa butter equivalent,|| —chocolate formulation,|| —sustainable agropreneurship,|| and —product innovation.||

The process of collecting and analyzing the literature was conducted in four main stages:

1. Identification of Relevant Documents

An initial search was conducted to gather all publications related to palm oil-based chocolate bar formulations, food product innovation, and the concept of sustainable agropreneurship. The initial search yielded approximately 110 publications, which were then downloaded for further review.

2. Source Selection

All collected documents were screened based on credibility (e.g., journals indexed in SINTA, Scopus, or Web of Science), recency (publications within the last six years), and relevance to the research objectives. This process resulted in 57 documents meeting the inclusion criteria.

3. Synthesis of Key Findings

The content of each source was analyzed to identify significant findings related to:

- a. Palm oil fat formulation technologies as cocoa butter substitutes (CBS) or cocoa butter equivalents (CBE).
- b. Physicochemical properties of the resulting chocolate products.
- c. Consumer preferences for palm oil-based chocolate.
- d. Economic, environmental sustainability, and market opportunity aspects.

Data from various sources were then thematically organized to facilitate further analysis.

4. Analysis of Linkages with the Sustainable Agropreneurship Concept

The synthesized findings were analyzed in relation to sustainable agropreneurship principles, such as efficient resource utilization, product innovation, environmentally responsible supply chain management, and local farmer empowerment. The descriptive-analytical analysis involved explaining the collected data, comparing findings across sources, and drawing relevant conclusions to develop a model for product development strategies.

The validity of findings was maintained through source triangulation, comparing results from various authors and publications to ensure consistency of information. This process aimed to produce an accurate, up-to-date, and comprehensive overview of the opportunities for developing palm oil-based chocolate bars as part of sustainable agropreneurship strategies in Indonesia (Snyder, 2019; Kitchenham et al., 2021).

RESULTS AND DISCUSSION

1. The Potential of Palm Oil Fat as a Cocoa Butter Substitute

Palm oil fat, particularly the stearin fraction obtained through fractionation, holds significant potential as a partial replacement for cocoa butter in chocolate bar formulations. Physicochemically, stearin exhibits a melting point ranging from 32–36°C and a β' crystallization pattern comparable to cocoa butter after undergoing enzymatic modification or interesterification (Pranoto & Hidayati, 2023). These characteristics are crucial as they determine the final texture of chocolate solid at room temperature yet melting smoothly in the mouth. Several studies have demonstrated that combining palm oil fat with cocoa butter equivalents (CBEs) derived from other vegetable oils can enhance fat stability and extend product shelf life. This potential positions palm oil fat as a strategic solution to reduce the Indonesian chocolate industry's dependence on imported cocoa butter, which is costly and subject to fluctuating global supply.

From a sensory perspective, recent research reveals that incorporating palm oil fat at proportions of 20–30% in chocolate bar formulations does not produce significant differences in taste, aroma, or mouthfeel compared to formulations using 100% cocoa butter, provided that proper tempering is applied (Sutanto et al., 2024). This is attributed to

the compatibility of palm oil's triglyceride profile with cocoa butter, particularly in the POP (palmitoyl-oleoyl-palmitoyl) and POS (palmitoyl-oleoyl-stearoyl) fractions, which contribute to a crisp texture that melts easily. Moreover, palm oil fat usage enables better control of chocolate mass viscosity, thereby facilitating molding processes and reducing the need for additional cocoa butter, which is relatively expensive. Thus, palm oil-based formulation innovations can serve as a cost-efficiency strategy without compromising product quality.

Beyond technical benefits, the potential of palm oil fat as a cocoa butter substitute carries positive implications for the sustainability and self-sufficiency of the national chocolate industry. The utilization of domestically produced palm oil fat can enhance the added value of palm oil within the country and create entrepreneurial opportunities for local agropreneurs in the downstream sector. Furthermore, palm oil offers higher oil yield per hectare than other vegetable oil crops, making its land use relatively more efficient (Wulandari & Saputra, 2022). By adopting sustainable palm oil principles and certifications such as the Indonesian Sustainable Palm Oil (ISPO) or the Roundtable on Sustainable Palm Oil (RSPO), the integration of palm oil fat in chocolate manufacturing can be positioned as an environmentally friendly and globally competitive innovation. The synergy between formulation research, sustainable agricultural practices, and targeted marketing strategies will strengthen palm oil fat's position as a cocoa butter substitute that is not only economically viable but also sustainable.

2. Economic Impacts for Agropreneurs

The utilization of palm oil fat as a partial substitute for cocoa butter in chocolate bar formulations has substantial economic implications, particularly for agropreneurs operating in the mid- to upper-market segments. Industry research indicates that the use of palm oil fat can reduce raw material costs by approximately 15–25% compared to formulations using pure cocoa butter (Siregar et al., 2023). This cost reduction is primarily driven by the greater price stability and affordability of palm oil fat in domestic markets, whereas cocoa butter prices tend to fluctuate and are heavily influenced by global market dynamics. Such savings provide agropreneurs with greater flexibility to reallocate capital toward product innovation, packaging improvements, or more aggressive marketing strategies. The resulting impact is enhanced competitiveness in both domestic and export

markets, especially for developing countries with price-sensitive consumer bases that still demand high quality.

Furthermore, lowering raw material costs can directly increase profit margins without compromising the sensory quality and texture of the final product. In the context of small and medium-sized enterprises (SMEs), higher profit margins can accelerate return on investment, thereby supporting long-term business sustainability. Several studies report that agropreneurs adopting palm oil fat-based chocolate formulations have achieved net margin increases of up to 12% compared to producers using 100% cocoa butter (Putri & Hanafiah, 2024). This cost advantage also enables the implementation of competitive pricing strategies, such as value pricing, which can expand the consumer segment while maintaining the product's premium positioning.

From a macroeconomic perspective, the domestic use of palm oil fat in the chocolate industry contributes to strengthening the palm oil value chain within the country. Additional demand for stearin and olein fractions used as cocoa butter equivalents (CBEs) can stimulate capacity expansion in the downstream sector, create new employment opportunities, and increase the income of local palm oil farmers (Hidayah et al., 2022). Moreover, this strategy can reduce dependence on imported cocoa butter, thereby conserving national foreign exchange reserves. Combining micro-level benefits for entrepreneurs with macro-level contributions to the national economy, the incorporation of palm oil fat into chocolate bar formulations represents a strategic measure aligned with the vision of food self-sufficiency and resource-based industrialization.

3. Environmental and Social Sustainability

The integration of palm oil fat into chocolate bar formulations offers not only economic benefits but also significant environmental sustainability advantages. By utilizing domestically sourced palm oil fat fractions, the chocolate industry can reduce dependency on imported cocoa butter, the production of which in producing countries often involves long supply chains with a high carbon footprint. Shortening the supply chain reduces transportation-related emissions and enhances energy efficiency in raw material distribution (Anwar et al., 2023). Moreover, the use of domestic palm oil derivatives supports diversification of palm oil applications within the food sector, adding value to a commodity that has traditionally been concentrated in cooking oil and biodiesel

industries.

From a social perspective, channeling palm oil fat into high-value products such as chocolate bars can create new employment opportunities in the downstream sector, particularly in fat fractionation and food manufacturing. Employment generation occurs not only in large-scale factories but also in small and medium-sized enterprises (SMEs) that participate in the supply chain from raw material processing to packaging and distribution (Kusuma & Wibowo, 2024). Furthermore, growing demand for certified sustainable palm oil fractions, such as Indonesian Sustainable Palm Oil (ISPO) or Roundtable on Sustainable Palm Oil (RSPO), incentivizes farmers to adopt more environmentally friendly cultivation practices. This shift yields positive outcomes for land conservation, waste management, and the mitigation of deforestation risks—issues that are often highly sensitive in the palm oil industry.

Nevertheless, the sustainability of palm oil integration in the chocolate industry hinges on the application of sustainable supply chain management principles. This entails ensuring resource efficiency, waste reduction, and biodiversity conservation across all stages from palm oil cultivation to chocolate production. Research indicates that sustainable intensification practices such as precision fertilization, use of high-yield varieties, and rehabilitation of degraded lands can enhance productivity without necessitating new land clearing (Rahman & Dewi, 2022). Such measures minimize environmental impacts while safeguarding social and economic benefits. Collectively, these strategies position palm oil integration in chocolate bar formulation as a business model aligned with the Sustainable Development Goals (SDGs), particularly Goal 12 on responsible consumption and production.

4. Consumer Acceptance

Consumer acceptance of palm oil fat-based chocolate bars is largely determined by sensory quality, encompassing flavor, texture, aroma, and visual appearance. Sensory evaluation conducted by Marzuki et al. (2022) demonstrated that incorporating up to 30% palm oil fat into chocolate formulations does not result in significant differences in taste and melt viscosity in the mouth, provided that proper tempering techniques are applied. The consistency of the fat crystal structure, closely resembling that of cocoa butter, is crucial in preserving the characteristic —snap when the chocolate is broken and the smooth

melting sensation on the palate. Consequently, processing technology plays a pivotal role in ensuring quality alignment with consumer preferences.

Beyond organoleptic attributes, consumer perception of ingredient origin and product sustainability values also influences acceptance levels. A study by Handayani and Putra (2023) revealed that urban consumer segments with higher environmental awareness tend to respond positively to products utilizing environmentally friendly local ingredients particularly when clear information regarding sustainability certification and the product's socio-economic impact is conveyed on packaging or promotional media. Educational efforts highlighting contributions to import reduction, empowerment of palm oil farmers, and carbon footprint reduction have been shown to enhance purchase intentions.

Marketing strategies that combine educational and emotional approaches are therefore relevant in broadening market acceptance. Producers can leverage narratives emphasizing support for local agropreneurs, food innovation based on domestic resources, and consumer participation in responsible consumption movements. According to Wulandari et al. (2024) consistent brand communication that underscores sustainability values can foster brand loyalty while creating differentiation in competitive markets. Thus, consumer acceptance of palm oil fat-based chocolate bars is not solely a matter of technical quality, but also a strategic effort to build consumer awareness and engagement with the broader sustainability mission.

5. Challenges and Development Strategies

The development of palm oil fat-based chocolate bars faces several challenges that require strategic solutions. One of the primary barriers is product quality standardization, particularly in ensuring consistent physicochemical properties such as melting point, texture, and storage stability. Variations in fatty acid composition among palm oil fat sources can influence their performance as cocoa butter equivalents (CBE), thereby necessitating standardized formulation and processing protocols (Harahap et al., 2022). Furthermore, to compete in international markets, products must comply with global quality standards such as the Codex Alimentarius and obtain food safety certifications, including ISO 22000 or HACCP.

Another challenge involves public perception and the negative stigma often associated with palm oil, frequently linked to issues of deforestation and environmental

degradation. This can affect consumer acceptance in certain market segments, particularly in countries with stringent sustainability regulations. According to Sutanto and Dewi (2023) one effective approach to overcoming this stigma is to ensure that the palm oil fat supply chain originates from plantations certified for sustainability, such as the Roundtable on Sustainable Palm Oil (RSPO) or Indonesian Sustainable Palm Oil (ISPO), and to communicate this transparently to consumers. Certification not only enhances product credibility but also opens opportunities to access premium markets that prioritize sustainability.

Effective development strategies should integrate continuous research, value-based local branding, and cross-sector collaboration. Research efforts can focus on processing technology innovations aimed at producing CBE with characteristics that more closely resemble pure cocoa butter while extending product shelf life. Branding that highlights local narratives such as the empowerment of palm oil farmers and reduced dependence on imports can serve as a differentiating factor in both domestic and international markets. Collaboration among industry, government, and research institutions is also critical to building an innovation ecosystem, providing incentives for producers, and expanding distribution networks. According to Wijaya et al. (2024), such multi-stakeholder synergy plays a vital role in accelerating the adoption of innovative products in international markets while strengthening Indonesia's position as a key player in the sustainable chocolate industry.

CONCLUSION AND IMPLICATIONS

The optimization of palm oil-based chocolate bar formulations, particularly through the utilization of stearin fractions as cocoa butter equivalents (CBE), has demonstrated substantial potential in supporting sustainable agropreneurship strategies in Indonesia. From a technical perspective, properly designed formulations are capable of maintaining the physicochemical and sensory characteristics of chocolate, thereby avoiding significant quality degradation compared to products made with pure cocoa butter. Economic advantages arise from a reduction in raw material costs of approximately 15–25%, enabling producers to offer more competitive selling prices while simultaneously increasing profit margins. From a sustainability standpoint, the use of domestically sourced palm oil reduces dependency on imports, strengthens local supply chains, and contributes to farmer empowerment and job creation within the food processing

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sector. When managed under the principles of sustainable plantation management, negative environmental impacts such as deforestation and soil degradation can be minimized, in line with the implementation of certifications such as the Indonesian Sustainable Palm Oil (ISPO) and the Roundtable on Sustainable Palm Oil (RSPO).

Despite its promising opportunities, the application of palm oil fats in chocolate bar formulations still faces a number of challenges, including product quality standardization, compliance with international certifications, and consumer skepticism toward palm oil. Addressing these challenges requires synergy among industry players, government bodies, and research institutions to foster technological innovation, develop value-driven local branding, and implement consumer education programs highlighting the economic, social, and environmental benefits of such products. Marketing strategies that emphasize quality, sustainability, and pride in local products can enhance market acceptance both domestically and internationally. Through a collaborative and sustainable approach, palm oil-based chocolate bars have the potential not only to emerge as a flagship national product but also to compete successfully in global markets as a model of integrated food innovation and sustainable agroindustry.

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