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Original Research Paper

Pineapple Waste Processing Design as Functional Food to Support Agrotourism in East Lombok, Indonesia

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Abstract

The abundant pineapple waste in East Lombok remains underutilized as a functional food resource and has not been integrated into sustainable agrotourism development, leading to environmental challenges and missed economic opportunities for local communities. This study aims to design a model for converting pineapple waste into functional food products within a zero-waste agrotourism and circular economy framework that supports community-based development. A descriptive qualitative literature review was conducted using reputable journals, BPS statistics, data from agricultural and tourism agencies, and regional planning documents. Thematic analysis identified the bioactive potential of pineapple waste, explored functional product innovations, and formulated integration schemes for agrotourism activities. The results show that pineapple peel, core, and crown contain bromelain, phenolic compounds, and dietary fiber that can be processed into fermented beverages, functional vinegar, peel tea, fiber flour, and high-fiber snacks suitable as agrotourism products. Integrating these products through workshops, demonstrations, tasting sessions, educational tours, and souvenir sales can enhance commodity value, strengthen green destination branding, and support the SDGs. Overall, the utilization of pineapple waste offers a synergistic strategy that links agriculture, food innovation, sustainability, and tourism. The study highlights the need to establish a circular economy–based pineapple agrotourism pilot model supported by product guidelines, food safety standards, innovation facilities, and collaboration among farmers, MSMEs, researchers, and local government.

Keywords: Agrotourism; Design; Functional food; Pineapple waste

INTRODUCTION

Pineapple (*Ananas comosus* Merr.) is a widely cultivated horticultural commodity in Indonesia and contains essential nutrients that offer significant health benefits. Pineapple fruit is known to be rich in vitamin C, vitamin A, and vitamin B6, as well as minerals such as potassium, calcium, phosphorus, and iron. It is also high in dietary fiber, phenolic compounds, and antioxidants, while bromelain an enzyme found in all parts of the plant provides additional therapeutic and anti-inflammatory functions valuable for preventing degenerative diseases (Egeten et al., 2016; Islam et al., 2015). These nutrients are distributed not only in the pulp, but also in the leaves, stems, tubers, and peel. However, a large portion of pineapple processing waste is still considered worthless and tends to cause environmental pollution if not properly managed (Salve & Ray, 2020). Recent studies demonstrate that pineapple waste contains bioactive compounds with potential as value-added raw materials for diverse applications in the food, health, and energy sectors (Emmanuella et al., 2025; Sarangi et al., 2023; Selvanathan et al., 2023; Nawangsarie et al., 2024).

The utilization of pineapple waste has been widely developed to produce high-value functional products, such as vinegar, biofuel, biogas, organic acids, fiber, and starch (Sarangi et al., 2023; Selvanathan et al., 2023; Nawangsarie et al., 2024). Waste from pineapple processing including peel, core, and crown can reach 30–50% of the total raw material (Meena et al., 2022), while other reports show waste composition may reach 50–60% depending on pineapple type and processing method (Polanía et al., 2023). Figure 1 illustrates the various by-products derived from pineapple processing along with their respective composition percentages. Although the potential applications of pineapple waste are scientifically well documented, in many production regions it remains underutilized and is still commonly used only as animal feed or simply discarded, despite containing bioactive compounds with high functional and nutritional benefits (Roda & Milena, 2019; Rivera et al., 2023).

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In East Lombok Regency, one of Indonesia's major pineapple production centers, waste handling and utilization remain suboptimal. The accumulation of waste contributes to problems such as soil and water pollution and leads to missed opportunities for economic and tourism-based innovation. The potential for transforming pineapple by-products into functional foods such as probiotic fermented beverages, fiber-rich products, and enzyme extracts has not yet been integrated with sustainable agrotourism development (Rivera et al., 2023; Selvanathan et al., 2023; Nguyen et al., 2023; Misran et al., 2023). As a result, the added value from waste processing that could enhance culinary and educational tourism experiences and strengthen local economic resilience is not fully realized (Paz Arteaga et al., 2024). The absence of a development model linking functional food innovation from agricultural waste with circular economy–based agrotourism represents an important gap that requires scientific and practical solutions.

Based on these conditions, research on processing pineapple waste into functional food products integrated with agrotourism is urgent to support waste reduction, increase local economic value, and contribute to achieving Sustainable Development Goals. This study aims to formulate a design for processing pineapple waste into functional food products connected to sustainable agrotourism development in East Lombok Regency. Specifically, this study seeks to: (1) identify the major bioactive compounds in pineapple waste and their functional potential, (2) map promising functional food products derived from pineapple waste, and (3) design an integrated model connecting these products with circular economy and zero-waste agrotourism initiatives. The outcomes of this research are expected to establish a scientific foundation for pineapple agrotourism that not only focuses on fresh fruit production, but also promotes waste innovation, public health benefits, and environmental sustainability

RESEARCH METHODS

Research Design

The design of this study is a descriptive qualitative research with a literature review approach, which also includes an explanation of the population and research sample (Kim et al., 2017). The population of this study consists of all scientific articles, journals, policy documents, and secondary data sources relevant to the theme of pineapple waste utilization, functional food product development, and agrotourism integration, representing the total number of potential references available within the research scope. The research sample consists of articles selected according to specific criteria, namely publications issued within the period 2013–2025 that explicitly discuss the composition and bioactive content of pineapple waste, techniques for processing functional food, and models for integrating agrotourism and community-based tourism development (Lima et al 2017). The research variables are represented by keywords used when searching for literature sources, such as "pineapple waste," "functional food," "bioactive compounds," "agrotourism," "tourism village," and "sustainable tourism development." The media used to obtain data sources include online academic databases such as Google Scholar, Scopus, ScienceDirect, PubMed, DOAJ, and Garuda Kemdikbud, supported by Publish or Perish and Mendeley for reference management (Febrianti et al., 2025).

Research procedure

The research procedure was carried out through several systematic stages (MacFarlane et al., 2022), namely: (1) determining research objectives and problem formulation; (2) selecting keywords using Boolean operators (AND/OR) to expand and narrow search results; (3) identifying relevant literature in academic databases; (4) screening documents based on predefined inclusion and exclusion criteria; (5) selecting final articles by eliminating duplicate or irrelevant sources; (6) extracting data from selected articles; and (7) synthesizing findings into thematic categories related to functional food innovation from pineapple waste and agrotourism integration. These stages follow the systematic review principle adapted from the PRISMA method to ensure transparency and methodological accuracy.

Sampling techniques

The secondary data sampling technique used purposive sampling, with the primary objective being to collect literature that clearly addresses specific topics such as pineapple waste, functional pangah, and agrotourism. This approach emphasizes content suitability over statistical representativeness Huynh, 2024). Snowball sampling, after identifying keyword sources, searches for reference lists and citations within the documents were performed to identify additional relevant literature (Lecy, & Beatty, 2012). Source selection was continued until data saturation was reached, the point at which the search no longer yielded additional literature that contributed important or novel findings.

Data analysis

The data analysis technique used is qualitative content analysis, which includes the processes of identifying, classifying, and interpreting concepts and research findings found in the reviewed literature. The data were then grouped thematically to generate conclusions relevant to the development of sustainable integrated agrotourism based on functional food processing from pineapple waste.

RESULTS AND DISCUSSION

Bioactive compound content of pineapple waste

Pineapple waste is a significant challenge in the modern tropical agro-industry, particularly in major pineapple-producing countries such as Indonesia, Malaysia, the Philippines, and Brazil. A literature review shows that global pineapple production annually exceeds 28 million metric tons, with Indonesia ranking fifth as the world's largest pineapple producer, with production reaching 1,837,000 tons per year (Illaningtyas et al., 2024). Approximately 25% of pineapples are processed into food products, while the remaining 75% are discarded as organic waste, causing economic losses and environmental problems.

Pineapple waste includes various biomass components considered to have no economic value, namely the peel, core, crown, stem, and leaves (table 1). Each of these components is rich in bioactive compounds with tremendous potential for conversion into high-value products (Paz Arteaga et al., 2024). Analysis of the chemical composition of pineapple waste reveals three main groups of bioactive compounds with significant biological activity and potential applications in the food and health industries (figure. 1) First, pineapple waste contains substantial amounts of carbohydrates, ranging from

66-88% on a dry weight basis, consisting of cellulose, hemicellulose, and pectin (Banerjee et al., 2017). Second, dietary fiber is an important component, with insoluble fiber content reaching 16-28% and soluble fiber 2-4% of the total dry weight. Third, pineapple waste is rich in essential minerals reaching 4-5% of the dry weight, including potassium, magnesium, calcium, and iron, which are essential for human metabolic function (Santos et al., 2021).

Table 1 Bioactive Compounds From Pineapple Waste

No	Reference	Pineapple Waste	Bioactive Components
1	(Moreira et al., 2022)	peel and crown	20 phenolic compounds (caffeic acid derivatives, flavone apigenin 6,8 C diglucoside), antioxidant, antiproliferative, anti-inflammatory activity
2	Polaki et al., 2024	Peel and waste trimmings	7 polyphenols (benzoic & cinnamic acid derivatives), total phenols & flavonoids, antioxidant activity, protein (including bromelain)
3	Santos et al., 2021	Shell and core	Nutritional composition (carbohydrates, fiber, minerals), total phenolics, antioxidant activity, bromelain activity
4	Meena et al., 2022	Shell,core, pomace, crown	Bromelain, pectinase/xylanase/cellulase enzymes, phenolic & flavonoid antioxidants, dietary fiber
5	Nordin et al., 2023	Shell and core	Total phenols (TPC), total flavonoids (TFC), antioxidant activity (DPPH), volatile compounds
6	Lasunon et al.,2022	peel, core , pomace	Total phenolics & flavonoids, antioxidant activity (DPPH)
7	Farid et al., 2024	peel	Nutrients (Ca, K, vitamin C, carbohydrates, fiber), sugars (sucrose, glucose, fructose), citric acid, bromelain; pharmacological effects
8	Soni et al., 2022	peel	Flavonoids, phenols, terpenoids, saponins, carotenoids, lignin, coumarin, ascorbic acid, gallic acid, catechin, epicatechin, myricetin, salicylic acid, ferulic acid; therapeutic & prebiotic effects
9	Olorunoje et al., 2025	Crown	Proximate composition (carbohydrates, fiber, protein, fat), phytochemicals (tannins, alkaloids, flavonoids, terpenoids, saponins)
10	Sukirah et al., 2023	Peel and pomace	Proximate composition, fiber, capacity as a prebiotic substrate for probiotics
11	Paz Arteaga et al., 2024	peel, core, crown, pomace	Bromelain, phenolics, dietary fiber; antioxidant, anticancer, antimicrobial, prebiotic activity
12	Bonsu & Boateng, 2025	peel, leaf, crown, core, stem	Phenolic, terpene, organic acid with pesticidal & antimicrobial activity

Pineapple waste not only serves as a production waste, but also a rich source of bioactive compounds that have high potential to be developed into value added functional food products. A recent study identified three major components in pineapple waste bromelain, phenolic compounds, and dietary fiber that have biological activity and potential to be utilized in various functional food formulations (Aili. et al., 2021). The three components are proven to provide antioxidant, anti-inflammatory, antimicrobial effects, as well as the ability to support digestive health, making pineapple waste an ideal candidate in the development of innovative food products. In addition, the application of processing technologies such as enzyme extraction, fermentation, and further drying can increase the concentration of bioactive compounds, thereby expanding their utilization opportunities in the nutritional food and beverage industry.

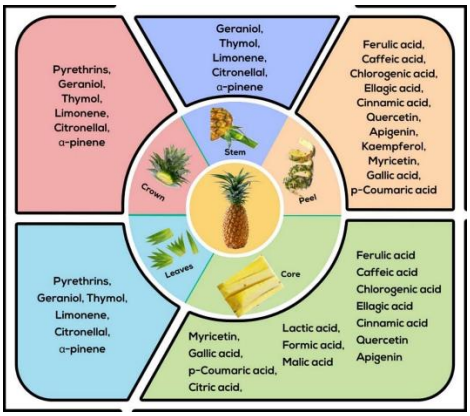

Figure 1 Pineapple waste and its derived bioactive compounds (Bonsu & Boateng, 2025)

Pineapple Waste Based Functional Food Product Design

This pineapple waste treatment design indicates that the fruit residue can be converted into a variety of high-value functional food products through the application of appropriate processing technology and innovatively developed formulations. Functional food products from pineapple waste can be classified into three main categories, namely functional beverages, food fortification ingredients, and bioactive components in supplements and nutraceutical products (Himanshu et al 2025) (Fig.2) The three product categories offer great market opportunities and have bioactive ingredients that complement each other in providing health benefits (Paz Arteaga et al., 2024). The design of pineapple waste treatment as a functional food product is as follows:

a. Fermented beverages are one of the most promising uses for pineapple waste. This waste can be fermented through an alcoholic process by *Saccharomyces* yeast or through lactic acid fermentation to produce beverages with a high content of bioactive compounds. Furthermore, pineapple waste can also be used as a raw material for vinegar production through a two stage process: alcoholic fermentation followed by oxidation to acetic acid by *Acetobacter* bacteria. This approach offers innovative opportunities for sustainable fruit waste processing. Further studies have shown that vinegar made from pineapple waste has potential to be marketed as a food seasoning, preservative, and healthy drink, due to its digestive health-promoting and antimicrobial properties (Bertan et al., 2022).
b. Detoxification drinks are a popular and sought-after product, combining concentrated phenolic extracts from pineapple waste with complementary ingredients such as lemon, ginger, and other herbs to support detoxification (Das et al., 2025). Sports recovery beverages integrate the active enzyme bromelain to support muscle recovery, reduce post-exercise inflammation, and maintain joint

mobility. Digestive wellness drinks are specifically designed to support optimal digestive function through a combination of bromelain, dietary fiber, and fermented prebiotics from pineapple waste. Immunity drinks combine the antioxidant and antimicrobial activity of phenolic compounds from pineapple waste with components that stimulate the immune response, such as vitamin C and zinc (Malaa et al., 2024; Santos et al., 202). Utilizing pineapple waste as a food fortification ingredient is an efficient and economical approach to increasing the nutritional content and bioactive components of commercial food products without the need for major reformulation.

c. Fiber flour made from pineapple waste obtained from the drying and grinding process of pineapple peel or core can be applied to various types of food products with the addition level that can be adjusted according to needs. Based on literature reviews, in breakfast cereal products, pineapple waste fiber powder can increase the total fiber content by 5-15% of dry weight without significantly reducing crispness or sensory acceptability. Processed pasta and noodle products can be fortified with 3-8% pineapple waste powder to increase fiber and antioxidant content, with research results showing that a substitution level of up to 10% is still acceptable to consumers from a sensory aspect even though the product color becomes darker. Snack products such as granola bars, energy bars, and crackers can also be fortified with pineapple waste powder or concentrated phenolic extract (Malaa et al., 2024; Nirmal et al., 2023).

d. Another potential application of pineapple peel waste extracts is tea, a simple yet strategic application of fruit waste into a functional beverage. The brewing process in hot water or a suitable solvent releases phenolic compounds, flavonoids, and other bioactive molecules, resulting in an easily consumed beverage with potential health benefits as antioxidants and natural bioactive agents (Das et al., 2025). Tea from pineapple peel waste represents a simple and effective application of pineapple waste as a functional beverage. Infusing pineapple peel in hot water extracts bromelain, phenolic compounds, and minerals, all available in an easily consumed form.

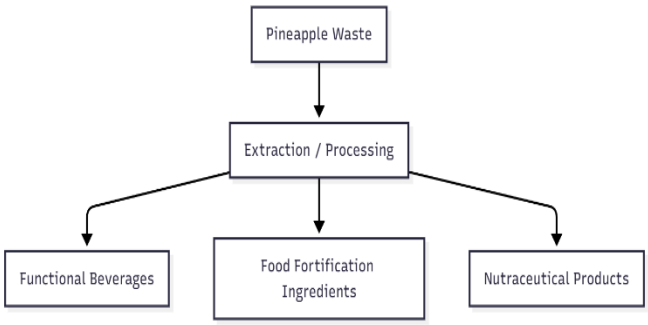

Figure 2. Pineapple Waste Based Functional Food ProductDesain

The Potential of Pineapple Waste as Sustainable Agro Tourism

According to data from the Ministry of Agriculture (Kementan 2024), pineapple is one of Indonesia's leading fruit commodities, with production reaching 238,806 tons across a total area of 199,371 hectares, consisting of 198,702 hectares of smallholder plantations and 669 large state plantations. The main production center is in East Java, with an average annual production of 117.93 thousand tons during the 2019–2023 period, followed by West Nusa Tenggara with 58.56 thousand tons, and Central Java with 53.50 thousand tons. These three provinces contribute approximately 92.97% of the total national pineapple production. West Nusa Tenggara (NTB) Province is one of the pineapple production centers, with an average annual pineapple production of approximately 58.56 thousand tons during the 2019–2023 period. Pineapples are cultivated in various regions of NTB, but East Lombok Regency is the main production center and serves as the backbone of the pineapple commodity in the province. The largest production area is located in Lendang Nangka Utara Village, Masbagik District, with a land area of approximately 900 hectares. This village is known as the "pineapple village" due to its abundant natural resources, including pineapples. Pineapples from Lendang Nangka Utara are of superior quality, characterized by their large fruit size and distinctive sweet flavor, providing added value and a distinct advantage to the region.

Given the high average pineapple production in East Lombok Regency, this region has significant potential to be developed as a pineapple-based agrotourism destination. However, integration between the pineapple farming sector and tourism is still limited, so the local economic potential has not been fully maximized. Lendang Nangka Utara Village, Masbagik District, East Lombok Regency, as one of the largest pineapple production centers in West Nusa Tenggara province, has a strategic opportunity to be developed into an agro-tourism destination that not only showcases the natural beauty and pineapple cultivation process but also offers educational experiences through processing derivative products, as well as local community empowerment activities. This development not only has the potential to increase the added value of pineapple commodities but also strengthen the creative economy, open new business opportunities, and promote socio-ecological sustainability in the region.

the high volume of pineapple processing activity generates a large volume of waste, including skin, core, crown, and leaves, that remains underutilized. This waste is largely discarded or used as animal feed, thus providing no added value. On the other hand, the high availability of pineapple waste presents a strategic opportunity to develop it as a raw material for functional foods with economic value for the local community. This makes it an ideal commodity for processing into value-added functional food products. Furthermore, increasing public awareness of the importance of healthy and sustainable food consumption has also driven various innovations in the food sector, including the use of pineapple waste and processed products as alternative functional foods. The innovation of processing pineapple waste into valuable products at an agrotourism site implements circular economy (zero-waste) principles. This provides an educational experience for visitors, creates sustainable micro-enterprises for the community, enhances moral and environmental values, and supports SDG3 by improving nutrition and reducing pollution (Fig.3)

A study conducted by Helviani et al. in 2024 found that Siompu oranges have great potential to be developed as a raw material for food innovation, given their abundant availability in Buton Regency and their various health benefits. These conditions make them an ideal commodity to be processed into functional food products with added value

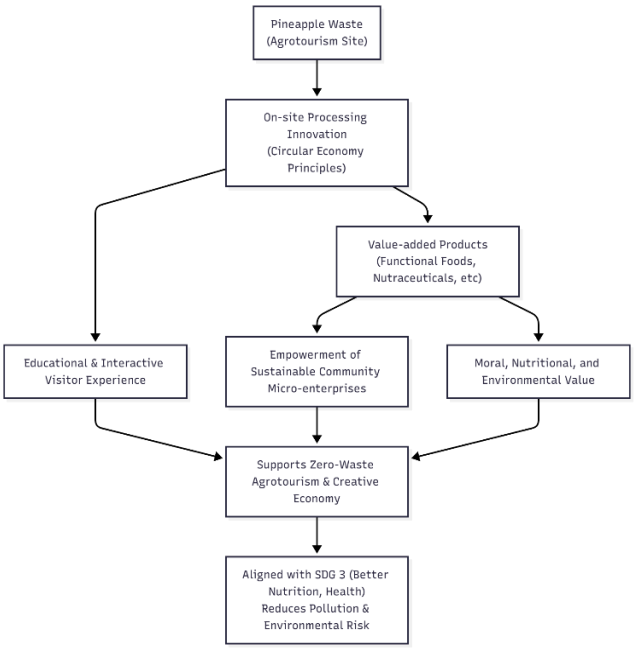

Figure 3. Pineapple Waste Potential Approach Model for Sustainable Agrotourism (Sarangi, et al 2023; Mir Cerda., et al 2023; Paz Arteaga., et al 2024)

Furthermore, increasing public awareness of the importance of healthy and sustainable food consumption has also encouraged various innovations in the food sector, including the use of Siompu oranges and their processed products as alternative functional foods. Thus, the development of pineapple agrotourism based on community empowerment can be a model that optimizes local potential, increases community income, and encourages the creative economy through the innovation of pineapple waste-based derivative products as functional foods. Contribution through products and nutritional improvement of pineapple waste processing into functional food products directly supports in table 2.

Table 2. Contributions of Turning Pineapple Waste into Functional Food Products

Functional Food Products	Main Contribution	Reference
Improvement of nutrition and public health	Functional products such as pineapple-skin tepache, kombucha, or high fibre snacks supply antioxidants, probiotics and dietary fibre that can raise nutrient intake and lower the risk of metabolic diseases.	Schroeder et al., 2019; Mortero et al., 2025
Exploitation of bio-active compounds	Pineapple peel is rich in bromelain, phenolic acids (e.g., caffeic-acid derivatives) and flavonoids (e.g., apigenin-6,8-C-diglucoside) that act as antioxidant, anti-inflammatory and antibacterial agents.	Aili et al., 2021; Bai et al., 2025
Diversification of local functional foods	Converting waste into pineapple-skin tea, fermented drinks (tepache/kombucha), syrup or fibre rich snacks expands the range of healthy.	Paz-Arteaga et al. , 2024
Organic waste reduction & environmental protection (Zero Waste)	Using peel that would otherwise be discarded for beverage or syrup production reduces solid-waste generation, lowers landfill methane emissions and supports a circular-economy model.	Sarangi et al., 2023
Local economic development & UMKM empowerment	"Pineapple-skin kombucha" can be produced at small-scale, packaged as a ready-to-drink health beverage, creating new market opportunities, increasing household income and strengthening microenterprises.	Ismail & Zaila Idris, 2025
Integration into sustainable agritourism packages	Demonstrations of waste-to-food processing, sales of healthy souvenirs, and storytelling about sustainability enrich agri tourism attractions beyond fresh fruit sales.	Helviani et al., 2024
Enhancement of food security and self reliance	Educating the public on functional foods made from local waste shows how indigenous resources can contribute to national food sovereignty and promote healthier eating habits.	Ismail & Zaila Idris, 2025

Integrating Product Development with Sustainable Agrotourism

In the context of agrotourism, utilizing pineapple waste as a base ingredient for functional foods can create a more engaging, educational, and sustainable tourism experience. Modern travelers are showing a high interest in educational and sustainability-based tourism, including the process of transforming waste into health products. The presence of functional products such as fermented drinks made from pineapple waste, bromelain extract, high-fiber snacks, or probiotic drinks can enrich the tourism experience while increasing economic opportunities for local businesses.

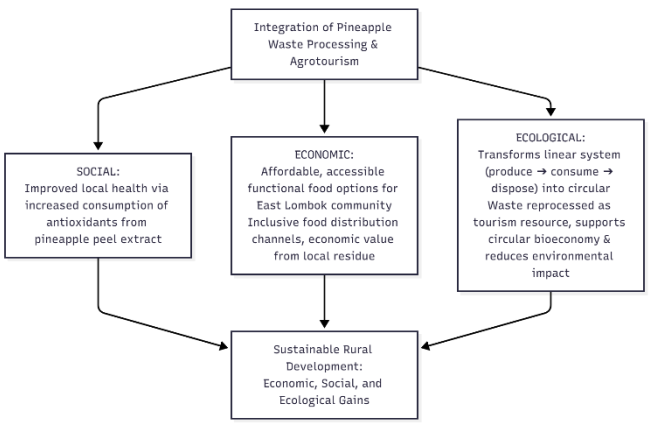

Figure 4. Integration between pineapple waste processing and agrotourism strategy

Pineapple waste is not merely a byproduct of production but a valuable resource that can be developed into functional food products. This approach aligns with the concept of a circular bioeconomy, which emphasizes the reuse of agricultural waste into value-added products, thereby reducing environmental impact and increasing production efficiency. Processing pineapple waste into functional foods not only adds economic value to local communities but can also be effectively integrated with agrotourism development in East Lombok. The farm-to-product concept allows tourists to directly witness the production process, from pineapple cultivation to processing waste into functional products, such as pineapple peel tea, fiber powder, or bromelain extract. This activity can be expanded through educational workshops that teach how to process waste into ready-to-consume products, making the tourism experience interactive and informative.

Table 3. The concept of integrating pineapple waste processing with sustainable agrotourism

Integration Aspect	Brief Description	Main Benefits	Practical Examples
Processing Pineapple Waste into Functional Products (Moreira et al. 2022; Aili et al. 2021)	Conversion of peel, core, and crown into fermented drinks, teas, fiber snacks, syrups, or phenolic extracts.	• High nutritional value (bromelain, antioxidants, phenolics) • Reduces organic waste •Opens functional-food market	Tepache / kombucha from peel – Drying peel →dietary-fiber powder – Extracting phenolics for supplements
Zero Waste Agrotourism Model Sarangi et al.,2023	Tourism flow shows full cycle: fresh fruit → waste → value-added product. Visitors learn circular-economy principles.	Eco-education • Adds tourist attraction • Enhances "green tourism" branding	Guided tours in mini-processing units – Hands-on workshops: fermentation, drying.
Economic Empowerment (UMKM & Community) Meena et al., 2022	Farmers & SMEs produce functional pineapple products for tourist markets.	•Aternative income • New jobs (women & youth) • Adds value to local commodities	–RTD pineapple-peel kombucha – High-fiber snacks at kiosks – Regional "Zero-Waste East Lombok" branding
Linkage to SDGs & Social Well Being (Aili et al., 2021)	Functional products support SDG 3 (health) and SDG 12 (responsible consumption & production).	•Better community health • Less environmental burden • Supports sustainable-development policies	Nutrition education on bromelain – Eco-labeling of tourist products
Technical & Policy Prerequisites (Aili et al, 2021;Liao et al.,2021)	Requires clean biomass sorting, safe processing (HACCP/GMP), and enabling local regulations.	• Ensures product safety & quality • Reduces health risks • Supports business scale-up	–On-farm segregation – HACCP certification – Micro-credit for equipment

These processed products can also serve as unique souvenirs based on local innovation, while strengthening East Lombok's image as a sustainable agro-tourism destination. This approach aligns with the principles of a circular economy and community empowerment, as it encourages the utilization of organic waste, creates jobs, and raises public and tourist awareness of healthy food consumption. Several studies have shown that integrating agro-tourism with tropical fruit waste processing can increase local economic value, encourage functional food innovation, and enrich the educational experience for visitors (Huang et al., 2011; Meena et al., 2022; Casa Rodríguez et al., 2023).

Integrating pineapple waste into functional food products such as peel tea, tepache/kombucha, vinegar, syrup, or high-fiber snacks within a zero-waste agrotourism model transforms waste into valuable bioactive resources (bromelain, phenols). This process is transparently presented to tourists through edutainment workshops that demonstrate the production chain from fresh fruit to the final product, thereby bringing the circular economy concept to life and raising health awareness. With low raw material costs, local UMKM can produce premium-priced "healthy souvenirs," opening up new income opportunities and diversifying household economies, while supporting SDG3 (nutrition) and SDG12 (responsible consumption and production). The success of this model requires a clean biomass supply, food safety standards, branding aligned with the tourism narrative, and coordinated collaboration between farmers, women's groups or UMKM, tourism operators, and local governments (Table 3).

Implementation Challenges and Recommendations

Processing pineapple waste into functional food integrated with agro-tourism has significant economic, educational, and environmental potential. However, implementation in East Lombok faces several key challenges, including:

1. Inconsistent waste supply due to seasonal pineapple production and the distribution of small-scale farmers, which can hamper production continuity.
2. Limited processing technology and local human resource capacity make it difficult to optimally implement the extraction of bioactive compounds and processing of functional food. This is due to varying levels of literacy and technical skills among the community. Some participants may have difficulty understanding the extraction, fermentation, packaging, or product quality testing processes.
3. Food safety regulations and quality standards pose obstacles if products fail quality testing, risking failure to market.
4. Production, logistics, and marketing costs can reduce profitability if the supply chain is inefficient or the product is poorly accepted by consumers.
5. Local community awareness and involvement need to be increased for sustainable production and agro-tourism schemes to be effective.

To address these challenges, several measurable recommendations can be implemented. Waste supply can be stabilized through partnerships with local farmers and structured collection schedules, as well as the use of a hub-and-spoke model for waste consolidation. Human resource capacity building can be achieved through technical training

and technology transfer for waste processing into simple to advanced functional products. Quality testing and food safety certification must be implemented to ensure products meet regulatory standards and gain market trust. Optimization of the logistics and marketing chain can be achieved through the formation of cooperatives/producer groups, educational branding, and the integration of tourism experiences (e.g., production demonstrations and product tastings). Finally, public awareness needs to be raised through education, workshops, and cross-stakeholder collaboration, so that pineapple waste processing can be economically, socially, and environmentally sustainable.

CONCLUSION

East Lombok demonstrates that fruit waste such as peels, stems, and crowns have high potential for conversion into value-added functional food products. Utilizing this waste not only supports environmental sustainability by reducing organic residue but also creates economic opportunities for local communities through integration with agro-tourism activities. The key to success lies in standardizing raw materials, hygienic process management, and implementing a centralized waste collection system from farmers or traders, ensuring consistent supply volume and continuity. Furthermore, community empowerment through processing and marketing training, as well as integrated digital promotions, can enhance the tourist appeal and educational value of agro-tourism. With this integrated approach, pineapple waste can be optimally utilized, creating high-quality functional products and strengthening East Lombok's position as a sustainable agro-tourism destination.

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