Review Article

Jurnal Apoteker Indonesia (JAI), 3(4), 170-183

Beyond Nutrition: Bioactive Profiles and Pharmacological Potential of Major Agricultural Commodities and By-products of Banyumas, Indonesia - A Narrative Review

Indra Yudhawan[1*], Binar Pratama[1], Suci Wulan Sari[2], Sifa Aulia Wicaksari[3], Mely Anita Sari[4], Putri Khaerani Cahyaningrum[1], Nur Amalia Choironi[1], Lulu Setiyabudi[1]

[1]Laboratory of Pharmaceutical Biology, Department of Pharmacy, Faculty of Health Sciences, Universitas Jenderal Soedirman, Indonesia
[2]Laboratory of Pharmaceutical Technology, Department of Pharmacy, Faculty of Health Sciences, Universitas Jenderal Soedirman, Indonesia
[3]Laboratory of Dietetic, Department of Nutrition Science, Faculty of Health Sciences, Universitas Jenderal Soedirman, Indonesia
[4]PT. Tapian Nadenggan Clinic, Sinarmas Group, East Kalimantan, Indonesia

ARTICLE HISTORY

Received:20 July 2026
Revised:05 August 2026
Accepted:15 August 2026

**corresponding author*
Email:
indra.yudhawan@unsoed.ac.id

ABSTRACT

Background: Banyumas Regency have a high diversity of agricultural commodities; however, their utilization remains largely confined to basic food and economic purposes. Additionally, numerous agricultural by-products and waste materials have not been maximally utilized. Purpose: This review aims to explore the bioactive profiles and therapeutic potentials of major Banyumas commodities to support public health, reduce dependence on imported pharmaceutical raw materials, and promote a circular economy. Methods: A narrative literature review was conducted using various reference sources and reputable journals, with an emphasis on current research. Results: Key commodities—such as cashew, coffee, rubber, clove, tobacco, sugarcane, coconut husk, and rice husk—demonstrate diverse pharmacological activities, including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, wound healing, and metabolic disorder-modulating effects. Conclusion: Beyond fulfilling nutritional requirements, these primary commodities and their associated waste products hold strong potential as alternative phytopharmaceutical materials, capable of advancing both the circular economy and public health

Keywords: *Banyumas commodities, bioactive profiles, therapeutic potential, raw materials, circular economy.*

INTRODUCTION

Banyumas is a regency located in the southwestern region of Central Java Province, covering an area of 1,327.60 km². The region's topography comprises lowlands and mountainous areas, traversed by the Serayu River and several smaller tributaries. Situated near the slopes of the active and fertile Mount Slamet, distant from the coastline, Banyumas features a humid tropical climate with temperatures ranging from 21.4 °C to 30.9 °C (Badan Pusat Statistik Kabupaten Banyumas, 2025). The topographically diverse regency experiences varying precipitation patterns: the northern region receives year-round rainfall with no distinct dry season (non-ZOM), marking Banyumas as one of the areas with the highest cumulative annual rainfall in Central Java (>3300 mm per year). Furthermore, the southern slopes of Mount Slamet serve as a critical water catchment zone and a primary hydrological recharge fortress for western Central Java, characterized by continuous precipitation throughout the year. The central region (Purwokerto and its surroundings) exhibits an extended wet season, the southern region displays a distinct seasonality between wet and dry periods, whereas the southwestern area experiences a more dominant dry season (Pusat Informasi Perubahan

Iklim BMKG, 2022). Collectively, these environmental factors provide diverse agroclimatic conditions that support a wide variety of agricultural commodities.

Banyumas have an extensive diversity of local commodities that can be leveraged to enhance regional economic value, encompassing up to 82 distinct commodities. These include rice (dry unhusked rice), coconut sap (nira), banana, corn, cassava, coconut, cardamom, durian, pine resin, rambutan, stink bean (petai), mango, melinjo, papaya, Chinese cabbage/mustard greens, cayenne pepper, avocado, sweet potato, duku, peanut, archidendron pauciflorum (jengkol), water spinach, sapodilla, curly red chili, Siamese orange, clove, cucumber, soybean, rose apple, eggplant, yardlong bean, tomato, breadfruit, among many others, excluding livestock feed and meat commodities (Badan Pusat Statistik Kabupaten Banyumas, 2026). Statistical data from recent years highlight several primary superior commodities in Banyumas (Banyumas, 2025; Dharmawan, 2025), namely rubber, coffee, coconut, nutmeg, pepper, tea, clove, tobacco, as well as food crops including rice, corn, cassava, coconut, and coconut sap (nira). Beyond agricultural commodities, Banyumas has also demonstrated achievements in waste management, a sector contributing 0.07–0.08% to the Regional Gross Domestic Product. Among the underutilized agricultural waste products are rice husks and coconut husks/shells (Badan Pusat Statistik Kabupaten Banyumas, 2026).

Currently, approximately 25% of Indonesia's demand for herbal raw materials is still met through imports (Banyumas, 2025; BPOM, 2022). As a developing country, a significant portion of Indonesia's population relies on traditional medicine (Ismat and Saputri, 2026). Furthermore, raw material supply frequently poses a challenge because many materials are not harvested from cultivated land. While researchers heavily focus on identifying therapeutic activities in medicinal plants and non-food/non-commodity species, several food commodities have proven effective in health applications. For instance, rice bran (a byproduct of rice milling) exhibits anti-inflammatory properties and promotes wound healing (Khuan, 2025), jicama demonstrates antioxidant activity (Nidyatama and Wahyuniari, 2026), and papaya leaves have antioxidant and tyrosinase-inhibiting activities (Simamora et al., 2026). Although primary food commodeities, these materials demonstrate proven health benefits. Additionally, waste products from major commodities (especifically rice husk and coconut husk/shell) hold substantial potential for optimization to maximize their economic value, driving sustainable growth and supporting a circular economy (Kirchherr et al., 2017; Zharif et al., 2024). Consequently, this review explores the health potential of these major commodities in depth to reduce reliance on imported herbal raw materials and elevate the economic value of each commodity.

METHODS

This article is based on a narrative literature review. The sourced come from the Google search engine database, with most of them obtained from Google Scholar searches and reputable journal with the keyword used in the search is "(commodity) activity". There are no limited time/criteria to filter the search. The inclusion criteria for this review is the use of primary literature, specifically original research articles published in peer-reviewed journals, and related souces which specifically evaluate and present data regarding the economy, ecology, bioactivity profile, and pharmacological activity of the commodities.Some are from textbooks or standard books and online article that are still related and trusted. The exclusion criteria are sources from secondary and tertiary literature (such as review articles) as well as all non-scientific publications and materials from secondary sources (including mass media, popular magazines, opinion pieces, and unofficial websites). At least 60% of the literature are from the last 10 years, while the other (maksimum 30%) is from any year.

RESULTS AND DISCUSSION

Banyumas Regency exhibits a highly diverse agricultural landscape. However, the potential of its primary commodities and agro-industrial by-products extends significantly beyond their conventional nutritional and economic utility. Extensive scientific evaluation demonstrates that these local commodities have robust bioactive profiles and high therapeutic potentials, encompassing antioxidant, antimicrobial, anti-inflammatory, and metabolic-modulating properties. The comprehensive review to assess these commodities, especifically cashew, coffee, rubber, clove, sugarcane, and tobacco, also with the by-product (coconut husk and rice husk) could be beneficial for the development of pharmaceutical potency, source, and also catalyzes the advancement of public health and a sustainable circular economy. We selected these commodities because they represent major commodities in terms of quantity and potency, and its applications are widely utilized with various application, giving it the potential for immediate and efficient development (see Table 1.). Consequently, this section narratively elucidates the latent health benefits and therapeutic efficacy underlying these principal commodities and the underutilized/by-product components

Table 1. Classification table for each commodity based on the strength of evidence and potency

Commodities	Major Commodities*	By-Product	Potency	Source
Cashew	Low	Yes (Dead Pseudofruit)	Medium	(Badan Pusat Statistik Kabupaten Banyumas (2026); Banyumas, B.P.S.K (2025))
Clove	High	-	High	
Coffee	High	-	High	
Coconut	Medium	Yes (Husk and Shell)	High	
Rice	High	Yes (Rice Husk)	High	
Rubber	High	-	High	
Sugarcane	High	-	High	
Tobacco	High	-	High	

*High: >100 Ton Annualy, Medium 20-100 Ton Annualy, Low: <20 Ton Annualy

Cashew (*Anacardium occidentale*)

Cashew (*Anacardium occidentale*) is a prominent agricultural commodity in Banyumas Regency. The most commonly utilized parts of the cashew plant are its pseudofruit and seeds. Structurally, it comprises approximately 10% seeds and 90% pseudofruits, with the latter containing 80% water and 10% sugar (Gutiérrez-Paz et al., 2024). If unharvested, the mature fruits inevitably fall and undergo natural fermentation in the soil. While cashew fruits and seeds are well-established in the agricultural and food sectors, this section elucidates the latent therapeutic potentials within these cashew components.

The cashew pseudofruit contains high amount of polyphenols, flavonoids, and tannins (Gutiérrez-Paz et al., 2024). Additionally, cashew apple juice exhibits a significant mineral composition, providing approximately 15% iron, 11.5% copper, and 3.7% zinc (de Lima et al., 2014). Furthermore, several phenolic compounds in cashew have been identified, including myricetin 3-O-rhamnoside, quercetin 3-O-galactoside, and quercetin 3-O-rhamnoside (Gordon et al., 2012). Notably, the ascorbic acid component exerts a substantially greater influence on the antioxidant activity of cashew compared to its phenolic constituents (Gordon et al., 2012).

The exudate has shown to have antidiarrheal activity. Heteropolysaccharide complexes extracted from the fruit exudate demonstrate antidiarrheal activity, which has been validated in acute, inflammatory, and secretory diarrhea models. Traditionally, this exudate serves as an antidiarrheal remedy in northeastern Brazil. The underlying mechanism is likely attributed to the inhibition of gastrointestinal motility, leading to reduced fluid and fecal secretion (Araújo et al., 2015). Another study demonstrated that cashew apple juice significantly reduced the incidence of peripheral blood DNA damage (by 60.82%) compared to the cyclophosphamide group. Furthermore, cashew apple juice decreased the average number of abnormal chromosome cells in the bone marrow by 53%. These findings indicate the potential of cashew apple as an antigenotoxic and anticlastogenic agent (de Carvalho Melo-Cavalcante et al., 2011). Sousa (2021) formulated a lyophilized cashew apple extract and conducted a safety analysis on zebrafish. The study revealed that this product is safe for consumption. In addition, the product also exhibits antimicrobial potential against *Listeria monocytogenes*.

Moreover, cashew apple juice has proven efficacy in improving physical fitness. Several middle-aged and elderly subjects were administered cashew apple juice at a dosage of 240 mg/day for 12 weeks. The results indicated signs of enhanced lower extremity muscle strength and cardiopulmonary fitness. The parameters assessed included the 30-second chair stand test and the 6-minute walk test. The underlying mechanisms supporting these effects require further elucidation; however, it is postulated that they are closely associated with the antioxidant activity of cashew apple juice (Kaewbutra et al., 2016).

Following the evaluation of the cashew pseudofruit, now we will change the focuses on the cashew seed. Cashew seeds exhibit a highly favorable nutritional composition, which includes β-carotene (9.57 μg/100 g DM), lutein (30.29 μg/100 g DM), zeaxanthin (0.56 μg/100 g DM), α-tocopherol (0.29 mg/100 g DM), γ-tocopherol (1.10 mg/100 g DM), thiamin (1.08 mg/100 g DM), stearic acid (4.96 g/100 g DM), oleic acid (21.87 g/100 g DM), and linoleic acid (5.55 g/100 g DM) (Trox, 2010). UPLC-HRMS/MS analysis revealed that cashew seeds contain phenolic compounds, particularly condensed tannins and flavanols, alongside (+)-catechin, (−)-epicatechin, epicatechin gallate, and procyanidins. Furthermore, experimental results demonstrated that cashew seeds have antimicrobial activity against *Staphylococcus aureus*, *Escherichia coli*, *Micrococcus luteus*, and *Bacillus cereus*. Additionally, cashew seeds exhibit free radical scavenging activity, with an IC_{50} of 12.35 ± 1.48 μg/ml (DPPH assay), 33.77 ± 1.04 μg/ml (ABTS assay), and 62.89 ± 2.1 μmol Fe^{2+} equivalent per gram of cashew nut testa (FRAP assay) (Sruthi et al., 2023).

Cashew seeds also show to have other therapeutic benefits, notably in weight management and cardiovascular function improvement. This was evidenced in an in vivo clinical model: an eight-week (8-week) randomized controlled-feeding study involving 68 overweight/obese adults (40 women, BMI: 33 ± 4 kg/m2). After the 8-week intervention, the group consuming cashew seeds exhibited no significant difference compared to the energy-restricted control group. All groups experienced reductions in body fat, body weight, and several other adiposity indicators (Meneguelli, 2024).

Coffee (*Coffea arabica*)

Coffee is another promising commodity cultivated in Banyumas. The coffee plant offers diverse pharmacological benefits, derived not only from its beans but also its leaves and fruits. Coffee beans contain chlorogenic acid, with concentrations ranging from 7.0–10.0% in Robusta and approximately 7.73% in Arabica beans. With appropriate formulation, this commodity could provide proper efficacy(Dewajanti, 2019;).

Robusta coffee beans, in particular, demonstrate unique therapeutic activity on ulcers. They have hygroscopic properties and a skin-compatible pH, thereby accelerating ulcer wound healing. Furthermore, Robusta coffee enhances immunological functions through the activation of leukocytes, polymorphonuclear neutrophils (PMNs), cytokines, matrix metalloproteinases (MMPs), and tissue inhibitors of metalloproteinases (TIMPs) to facilitate autolytic debridement. Clinical trials evaluating Robusta coffee on various wounds, including diabetic ulcers, reported favorable clinical outcomes with accelerated healing rates. Wounds treated with dry Robusta coffee healed more rapidly, demonstrating granulation tissue growth without infectious complications, compared to the control group receiving conventional 0.9% NaCl therapy (Amalia, 2020). The coffee fruit also exhibits equally distinct therapeutic efficacy. Administration of coffee fruit extract significantly improved renal tubular morphology and reduced TNF-alpha levels compared to the negative control group. The optimal dosage for this nephroprotective effect was observed at 200 mg/kg BW. These findings indicate the robust potential of coffee fruit to be developed as a novel nephroprotective agent (Siregar et al., 2026).

Coffee leaves also exhibit therapeutic activities. Widianingsih (2025) conducted a phytochemical screening on Robusta coffee leaves and fruit peels. The results indicated that both components contain alkaloids, flavonoids, phenolics/tannins, saponins, and terpenoids. Coffee leaves demonstrate proven antipyretic efficacy. Treatment in murine models administered with Arabica coffee leaf infusion showed a reduction in fever temperature nearly equivalent to the positive control group (paracetamol). The most effective concentration was 80%, whereas the 40% and 60% concentrations yielded inferior antipyretic effects compared to the 80% dosage (Pradana, 2022). In addition to the leaves, Arabica coffee fruit peels also exert antipyretic effects, with paracetamol as a positive control (Naomi et al., 2023). Furthermore, coffee leaves demonstrate anti-inflammatory activity. Evaluation using the edema induction method across various doses of coffee leaf extract indicated significant anti-inflammatory effects. The optimal outcome was achieved at a coffee leaf extract dosage of 180 mg/kg BW, achieving an inhibition percentage of 71.66% at the fifth hour. This result outperformed the positive control (diclofenac sodium 0.9 mg/kg BW), which recorded an inhibition of 66.91% (Wenas et al., 2020).

Coffee leaves also demonstrate antidiabetic potential. The extract treatment groups yielded consecutive blood glucose reductions of 47.05%, 56.93%, and 72.48%. Robusta coffee leaf extract exhibits antidiabetic activity with no significant difference compared to metformin ($p > 0.05$). The lowest mean AUC value and the most substantial percentage of blood glucose reduction were achieved by the ethanolic extract of coffee leaves at a dosage of 236 mg/kg BW. The ED_{50} value was determined to be 126.90 mg/kg BW (Shiyan et al., 2017).

Rubber (*Ficus elastica*)

The rubber plant is a prominent commodity, and its latex has been widely utilized for extensive applications. Besides the latex, another part of the rubber plant, especially its elaves,a also exhibits therapeutic properties. Rubber leaves contain phenolic compounds. A phytochemical screening indicated that rubber leaves yielded a bluish-black complex following the addition of $FeCl_3$ and tested positive in the TLC-citroborate assay, with a flavonoid content of 405 mg/g gallic acid equivalent and 82.94 mg/g quercetin equivalent (Maulana, 2019). Consequently, rubber leaves demonstrate proven antioxidant properties. Handayani (2020) reported that rubber leaf extract exhibits an antioxidant IC_{50} value of 78.39 µg/mL, compared to quercetin at 7.62 µg/mL. A DPPH assay conducted by Yani (2024) yielded IC_{50} values of 531.90 µg/mL for the n-hexane fraction and 188.06 µg/mL for the ethyl acetate fraction. Furthermore, Hasyim (2023) performed a FRAP assay, obtaining an antioxidant activity of 26.692 mg/g quercetin equivalent. This antioxidant effect is studied by Ginting (2020), who also identified components such as quercetin, myricetin, morin, and eleutheroside B within rubber leaves.

Rubber leaves offer several other health benefits, including anti-inflammatory properties. Studies indicate that both ethanolic and ethyl acetate extracts of rubber leaves could exhibit anti-inflammatory activity, with IC_{50} values of 31.24 μg/mL and 37.89 μg/mL, respectively, compared to the positive control at 9.2 μg/mL (Hasyim et al., 2023). Rubber leaves also demonstrate potency to be developed as antimicrobial agents. The ethanolic extract of rubber leaves exerts proven antimicrobial activity against Staphylococcus aureus at concentrations ranging from 10–40%, although the optimal concentration is 50%. Inhibition zone assays showd a result of 7.3 mm zone at a 10% concentration and a 16.3 mm zone at a 50% concentration, whereas the tetracycline control yielded a 42.3 mm zone (Zukhri and Nurhaini, 2019).

Regarding weight and caloric management, rubber leaves also demonstrate potency as alpha-glucosidase inhibitors. Fauzaan (2022) evaluated rubber leaf extract in vitro via enzymatic reactions, using an enzyme concentration of 0.1 U/mL and a 6 mM substrate concentration at a 405 nm wavelength, with acarbose as the control. The results showed that the rubber leaf extract have alpha-glucosidase inhibitory activity at 0.448 μg/mL, demonstrating greater potency than acarbose at 100.06 μg/mL. This highlights the potential of rubber leaf extract for development in novel alpha-glucosidase inhibitor drug discovery. Additionally, research by Putri (2020) provided evidence that rubber leaf extract acts as an antiplatelet agent. This was evaluated using aggregometry on platelet-rich human plasma induced by ADP, epinephrine, and thrombin, using ticagrelor (20 mM), yohimbine (10 μM), and FR 171113 (60 μM) as reference controls. The findings revealed that aqueous and ethanolic extracts of rubber leaves at 100 μg/mL effectively inhibited epinephrine-induced platelet aggregation, achieving inhibition percentages of 37.78% ± 0.96% and 28.89% ± 0.96%, respectively. The ethanolic extract yielded superior results compared to the aqueous extract, warranting further investigation to elucidate the ethanolic extract constituents responsible for the antiplatelet activity of rubber leaves.

Other than the leaves, some parts of the rubber plant can also be utilized, although this is less advantageous as it may reduce latex productivity. The specific part is the stem bark. Rubber stem bark demonstrates the potency as a larvicide. Research showed that the ethanolic extract of rubber stem bark exerts toxic effects, exhibiting an LC_{50} of 277.24 ppm in the Brine Shrimp Lethality Test (BSLT) (Arif et al., 2013; Putri et al., 2013; Wardana et al., 2013; Wardani et al., 2013).

Clove (*Syzigium aromaticum*)

Clove has been widely used in healthcare; therefore, health-related discussions concerning cloves may not be as extensive or comprehensive as in the other existing literature. Nevertheless, this section focuses on the specific parts of the clove plant. Several parts of the clove plant contain beneficial constituents and therapeutic properties.

Flower Buds (Clove Buds): Clove buds represent the most extensively investigated plant part. Harvested prior to opening, clove buds serve as the primary plant part and contain up to approximately 18% essential oil. The major constituents of clove buds include eugenol, eugenyl acetate, beta-caryophyllene, alpha-humulene, flavonoids, tannins, gallic acid, and various phenolic compounds. These constituents impart diverse activities, including antioxidant, antimicrobial, anti-inflammatory, antidiabetic, anticancer, neuroprotective, antifungal, preservative, larvicidal against Aedes aegypti, and analgesic properties. Additionally, clove buds are widely used in food, pharmaceutical, and cosmetic industries as natural preservatives, functional food ingredients, and flavoring agents.

Clove leaves contain essential oils consisting of eugenol, alongside beta-caryophyllene, alpha-humulene, phenolic compounds, and flavonoid. Clove leaves has shown to have several activities, include antioxidant and antimicrobial effects. Additional potential activities, such as anti-inflammatory, antidiabetic, and natural insecticidal properties, are also present, although they require further investigation. The research and application potential of clove leaves remains wide open.

Clove stems contain chemical components consist of essential oils comparable to those found in the flower buds, although at significantly lower concentrations. This plant part holds potential for utilization as a raw material for essential oils and biofuels. Research regarding this specific part remains limited. Clove fruit contains essential oil components and phenolic compounds. In Traditional Chinese Medicine, clove fruit is frequently used as a component in therapeutic formulations. Comprehensive discussions regarding clove fruit remain scarce. Furthermore, adequate evaluation of clove seeds is similarly lacking. Consequently, the plant parts discussed before, is still hold substantial potential for further research and development (Abdul Aziz et al., 2023; Cortés-Rojas et al., 2014; Haro-González et al., 2021; Xue et al., 2022).

Tobacco (*Nicotiana tabacum*)

Tobacco is widely used as a raw material for cigarette production. This section elucidates the components of tobacco associated with its health functions, provided it is prepared appropriately. Tobacco leaves contain flavanones and odoratenin. Experimental results indicate significant antioxidant effects. Tobacco leaf extract demonstrates antioxidant potential; specifically, odoratenin exhibited strong free radical scavenging activity against ABTS, yielding an IC_{50} value of 23.74 μM (compared to trolox at 31.32 μM) (Putri and Fatmawati, 2019). Furthermore, tobacco leaves comprise 49 total phenolic compounds, including phenolic acids (14), flavonoids (30), and other polyphenols (5); the aqueous extract yields the highest proportion of condensed tannins, while the methanolic extract contains the highest concentration of phenolics and flavonoids (Zou et al., 2021).

Tobacco leaf extract exhibits potential antimicrobial activity. The methanolic extract at a 60% concentration demonstrated antibacterial activity against 6 out of 9 isolated bacteria, with a significant effective concentration observed at 25 mg/mL (Akinpelu and Obuotor, 2000). Additional studies showed similar clinical efficacy. This was evidenced in assays against clinical biofilm-producing and highly resistant bacterial strains. The investigation evaluated nine pathogenic bacteria: three microbial type culture collection strains, four multidrug-resistant human clinical isolates, and two biofilm-forming uropathogenic bacteria resistant to chloramphenicol, tetracycline, erythromycin, clindamycin, amikacin, penicillin, ampicillin, nalidixic acid, and gentamicin. All tested bacteria were cultured in nutrient broth at 37°C. The ethyl acetate extract of tobacco leaves proven to have inhibitory activity against six of the nine tested bacteria. This activity is postulated to be mediated by the presence of pyridine, 3-(1-methyl-2-pyrrolidinyl)-(S)- in the tobacco leaves (Ameya et al., 2017). Further research by Malik (2015) demonstrated potent antibacterial effects against three pathogenic bacteria, namely *Staphylococcus aureus* (Gram-positive), *Escherichia coli*, and *Pseudomonas aeruginosa* (Gram-negative). Tobacco leaves also contain lignan derivatives such as nicotnorlignan, nicotlacone A, and sequirin, benzodioxane. These derivatives from the leaf extract were evaluated against the C8166 cell line. Cytotoxicity against C8166 cells (CC50) was assessed using the MTT assay, whereas anti-HIV-1 activity was evaluated through the inhibition of HIV-1-induced cytopathic effects. The findings indicate the potential of tobacco leaf extract as an anti-HIV agent (Gao et al., 2012). In other study, tobacco leaf extract exhibits antiparasitic efficacy. Notably, this effect applies comprehensively to diverse parasites (nematodes and lice) but is inactive against insects (Schorderet Weber et al., 2019). The anthelmintic activity is supported by an in vitro study by Iqbal (2006), demonstrating that the ethanolic extract of tobacco leaves exerts anthelmintic activity against Haemonchus contortus.

Another therapeutically active part is the tobacco root, which demonstrates antioxidant, antimicrobial, and antiproliferative potential. This evidence is obtained by evaluating hexane, acetone, and methanolic extracts. These extracts, alongside trolox, exhibited potent and significant antioxidant activity with IC_{50} values of 2, 6, 21, and 2 μg/mL, respectively. Meanwhile, the most potent antimicrobial activity was achieved by the acetone extract, followed by the hexane and methanolic extracts. Regarding antiproliferative potential, both the hexane and acetone extracts exerted strong and significant antiproliferative effects, followed by the methanolic extract. This is likely mediated by cell growth arrest or cell death induction. Study of the effect of the acetone extract on caspase-3 activity also revealed that this extract induced an apoptotic effect twice as potent as the chemotherapeutic agent doxorubicin (Al-Lahham et al., 2020).

Sugarcane (*Saccharum officinarum*)

Sugarcane is a widely distributed commodity in Indonesia. This section elucidates health-related aspects of sugarcane and its specific anatomical parts that confer therapeutic benefits. Sugarcane (*Saccharum officinarum*) demonstrates therapeutic efficacy in alleviating hyperuricemia. The primary bioactive constituents responsible for reducing hyperuricemia levels are sugarcane polyphenols (SP). Network pharmacology approaches and in vivo animal models indicate that the administration of low, medium, and high doses of SP significantly reduces serum uric acid (UA) levels in hyperuricemia-induced rats by 19.77%, 25.42%, and 45.54%, respectively. The mechanism of UA reduction is mediated through the inhibition of hepatic xanthine oxidase and the enhancement of UA excretion. These sugarcane polyphenols are derived from the extraction of byproducts generated during the sugar production process (Li et al., 2025).

Sugarcane also beneficial for prevention of infectious disease. In Ibibo, Nigeria, sugarcane is traditionally used as a medicinal remedy for infectious diseases such as malaria. Current research focuses on evaluating the antiplasmodial effects of sugarcane leaf extracts and fractions. The leaf extracts and fractions exhibit moderate activity against Plasmodium falciparum, with the dichloromethane fraction demonstrating the most potent activity (EC_{50} = 15.4 μg/mL) (Okokon et al., 2022). Furthermore, Polyphenol-Rich Sugarcane

Extract (PRSE), extracted from sugarcane molasses, exhibits antiviral activity against the Influenza A Virus (IAV). The inhibition by PRSE is dose-dependent but remains within non-toxic concentration limits. The antiviral mechanism of PRSE is strictly restricted to the inhibition of the early stages of viral infection (Tang et al., 2024).

Aqueous sugarcane extract exerts significant effects on the central nervous system and motor behavior in animal models, thereby demonstrating potential psychostimulant and anxiolytic-like effects via the dopaminergic pathway. In the Open Field Test evaluating locomotor activity, the aqueous extract (AE) increased locomotion and decreased rearing behavior, without affecting freezing or grooming responses. In the Rotarod Test evaluating physical coordination, AE improved motor performance and body balance. The Elevated Plus Maze Test assessing anxiety levels revealed that AE significantly reduced anxiety. In the Inhibitory Avoidance Test evaluating cognition and memory, AE did not alter or affect fast-learning capabilities or associative memory (Ziroldo et al., 2024).

An integral anatomical part of the plant is the sugarcane tip. Sugarcane tips contain an abundant composition of phenolic compounds. These constituents comprise free polyphenols (SPF) and bound polyphenols (SPB). Studies indicate that the concentration of bound polyphenols is highly abundant in sugarcane tips (31.9 ± 0.9 mg GAE/g DW) compared to free polyphenols (3.4 ± 0.1 mg GAE/g DW). The measurement is based on Gallic Acid Equivalent (GAE). Phenolic compound profiling with Ultra Performance Liquid Chromatography-Electro Spray Ionization, with Quadrupole Time of Flight- Mass Spectrometry (UPLC-ESI-QTOF-MS/MS) instrumentation identified 44 types of free phenolic compounds and 31 types of bound phenolic compounds. Furthermore, SPB is reported to exhibit stronger antioxidant activity compared to SPF (Huang et al., 2025).

Lignin extracted from sugarcane bagasse (SCB), an agro-industrial byproduct of sugar production, demonstrates significant potential as a cosmetic ingredient candidate due to its capacity to absorb ultraviolet radiation and its antioxidant activity. High-purity lignin (>92%) extracted from SCB was evaluated in vitro and in vivo to determine its Sun Protection Factor (SPF) and UVA-PF. Experimental results indicate that SCB lignin is safe for topical application. Moreover, both in vitro and in vivo assays demonstrate that the lignin-incorporated BB cream provides broad-spectrum UV protection. Consequently, SCB lignin serves as a multifunctional and safe cosmetic ingredient (Antunes et al., 2023).

Coconut (*Cocos nucifera*) Shell and Husk

Coconut is a widely utilized agricultural commodity, predominantly harvested for its water and meat. Conversely, the husk and shell are typically allocated for fuel. However, their health-related applications remain minimal. This review outlines several relevant studies to elevate the therapeutic and economic value of this coconut waste prior to its terminal processing as fuel.

The coconut shell exhibits various therapeutic properties. Its chemical composition generally comprises 30-35% cellulose, 25-30% hemicellulose, and 30-45% lignin. These constituents form a dense network of lignified stone cells (sclereids) and embedded vascular bundles, conferring high impact resistance (Schmier et al., 2020). This anatomical part can be used as a pharmaceutical raw material, specifically for activated charcoal production. Mozammel (2002) investigated the synthesis of activated charcoal from coconut shells, determining the optimum activation time and impregnation ratio at 40% and 600°C, respectively.

A frequently popular derivative product of the coconut shell is liquid smoke, a combustion byproduct. Liquid smoke contains tannins, saponins, and certain samples also yield steroidal compounds. This liquid smoke exerts antimicrobial efficacy. Extractions using petroleum ether and ethyl alcohol demonstrated inhibitory effects against *Staphylococcus aureus, Escherichia coli*, and *Candida albicans*. Consequently, liquid smoke serves as a viable natural preservative (Kailaku et al., 2017; Mazaya et al., 2020). Several studies have successfully applied liquid smoke in the preservation of fish balls (Zuraida et al., 2011). Beyond its antimicrobial and preservative functions, liquid smoke demonstrates proven wound-healing activity. It accelerates wound healing, presumably through a mechanism that increases fibroblast proliferation, although further investigation is warranted (Tarawan et al., 2017).

The coconut husk is more widely utilized and extensively investigated compared to the coconut shell. This is understandable as the majority of coconut waste comprises the husk, whereas the shell is merely a thin, hard layer and generally presumed to lack significant therapeutic efficacy. The coconut husk contains ten phenolic compounds, including gallic acid, 4-hydroxybenzoic acid, ferulic acid, syringic acid, and epicatechin. Its chemical composition is also influenced by pretreatment processes. The total phenolic content (TPC) of fresh coconut husk expressed with gallic acid equivalent (GAE) is 64.2 mg GAE/g dry weight, which is significantly higher than the values observed following Oven Drying (OD) and Microwave Drying (MD) processes, recorded at 35.8 and 45.5 mg GAE/g dry weight, respectively. MD-treated coconut husk exhibited an increase in gallic acid, 4-hydroxybenzoic acid, ferulic acid, syringic acid, and epicatechin content compared to fresh husk; meanwhile, both OD and MD treatments resulted in decreased levels of vanillic acid, vanillin, catechin, and kaempferol (Valadez-Carmona et al., 2016). Irondi (2017) ranked the potential antioxidant constituents in coconut husk extract as follows: the flavonoid content hierarchy is quercetin > apigenin > kaempferol > rutin, whereas the phenolic acid hierarchy is p-coumaric acid > chlorogenic acid > gallic acid > caffeic acid.

Coconut husk exhibits antioxidant potential. This was evaluated using the DPPH radical scavenging and ferrous ion chelating assays. The total phenolic content, expressed as mg gallic acid equivalent (GAE) per gram of extract, was recorded at 32.24 mg GAE/g in the mesocarp (husk). The radical scavenging activity, expressed in mmol Trolox equivalent (TE) per gram of extract, demonstrated a value of 119.96 mM TE/g. Meanwhile, the reducing capacity yielded a value of 751.89 mM Fe^{2+} (Rodiah, 2018). Antioxidant activity increased across various concentrations (50–200 mg/L) in a linear dose-dependent manner (Buamard and Benjakul, 2017). Conversely, antioxidant activity can also decline following certain treatments. Heating via oven and microwave can diminish the antioxidant activity of coconut husk, with microwave heating demonstrating better antioxidant activity compared to oven heating (Valadez-Carmona et al., 2016). The 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity and metal chelating activity decreased by up to 50% when heated above 90°C for more than 60 minutes (Buamard and Benjakul, 2017). In addition to antioxidant properties (Ferric Reducing Antioxidant Power/FRAP assay), coconut husk exhibits anti-acetylcholinesterase (anti-AChE) activity. Anti-AChE activity and FRAP values strongly correlate with total phenolic content. Quercetin, kaempferol, and gallic acid demonstrate potent inhibitory activity against AChE. Generally, the total phenolic content in the form of soluble phenolics (247.83 ± 1.52 mg GAE/g dry weight) in coconut husk is significantly higher compared to insoluble phenolics (132.77 ± 1.36 mg GAE/g dry weight) (Li et al., 2021).

Coconut husk demonstrates proven antimicrobial activity. The ethanolic extract exerts concentration-dependent antimicrobial activity against cariogenic organisms and Candida species. The resulting inhibition zones ranged from 4.6 mm to 16.3 mm; however, this efficacy was lower than that of chlorhexidine. The Minimum Inhibitory Concentration (MIC) ranged from 50 mg/mL to 75 mg/mL (Jose et al., 2014). Furthermore, the aqueous extract of coconut husk exhibited similar properties. It yielded concentration-dependent inhibition zones ranging from 4.44 mm to 15.33 mm against several oral pathogenic organisms (*Streptococcus mutans, Streptococcus salivarius, Streptococcus mitis, and Lactobacillus acidophilus*) (Cyriac, 2013). Notably, the studies which was mentioned before, primarily focused on bacteria and oral health. Additionally, the condensed tannin content in coconut husk exhibits anticorrosive potential, thus opening avenues for further research concerning the antibiofilm effects of coconut husk (Guedes et al., 2018).

Another study highlighted the preservative effect of coconut husk extract on the shelf-life of Asian seabass (Lates calcarifer) slices. Seabass slices treated with concentrations of 200 ppm and 400 ppm exhibited a substantially extended shelf-life compared to the control group (9 days versus 3 days, a threefold increase). A concentration of 200 ppm can be used as a natural preservative to prolong the shelf-life of Asian seabass slices without exerting adverse effects on their sensory properties. Moreover, this serves as an approach to use coconut husk as an alternative source for natural food additives (Olatunde et al., 2019). Interestingly, coconut husk has also been applied as a phytobiotic feed supplement in broiler chickens, capable of suppressing pathogenic bacterial growth while promoting beneficial microbiota in the avian digestive tract (Rusdi et al., 2022). This presents opportunities for further human studies regarding its potential probiotic-like effects.

Coconut husk also demonstrated antidiabetic potency. Blood glucose levels significantly decreased in alloxan-induced diabetic rats treated with the aqueous extract of coconut husk. Furthermore, histopathological studies demonstrated comparable regenerative capabilities in both the extract-treated rats and those receiving Daonil and Metformin. This efficacy is comparable to the combination of Daonil and Metformin, indicating its potential as an effective adjunctive therapy in the management of diabetes mellitus (Victor and E., 2012).

Rice Husk (*Oryza sativa*)

Rice husk is an agricultural byproduct derived from the rice harvesting process. It is conventionally utilized as fuel, planting media, organic mulch, or livestock bedding. This review evaluates the therapeutic potential of rice husk to elevate its functional and economic value.

Rice husk contains tocopherols and exhibits potential as an antioxidant. Wanyo (2014) investigated the antioxidant activity of rice bran, rice husk, and milled rice husk. The treatments used hot air, far-infrared radiation (FIR), and cellulase enzymes, which were then compared against raw samples. Overall, the FIR-treated group demonstrated higher DPPH radical scavenging activity, ferric reducing antioxidant power (FRAP), and total phenolic content (TPC) compared to the hot air and cellulase treatments across all sample types, and no alterations in content were observed. Additionally, the gamma-oryzanol content in cellulase-treated milled rice husk increased significantly. Particle size reduction of the husk proved to exert a positive impact on enhancing antioxidant activity, alongside gamma-oryzanol and phenolic compound levels. Kim (2011) evaluated rice husk extract, which demonstrated antioxidant activity and subsequent spectrophotometric analysis revealed the presence of flavonoids and gamma-oryzanol. Minh (2018) investigated various solvents and extraction conditions to optimize the efficacy of the antioxidant and antimicrobial potentials, alongside the chemical constituents of rice husk. The use of distilled water at 100 °C and the ethyl acetate (EtOAc) extract demonstrated high potential regarding total phenolic content (TPC), total flavonoid content (TFC), and DPPH radical scavenging activity. Treatment using ethyl acetate (100 °C, 1 hour) combined with 100% MeOH demonstrated the highest percentage of lipid peroxidation inhibition (LPI) at 86%. These findings indicate that the EtOAc extract of rice husk serves as a potential natural antioxidant source. Generally, the application of a 100 °C temperature for 2 hours, combined with EtOAc or 10% MeOH, optimally extracts the chemical constituents and maximizes the antioxidant capacity within the rice husk. Gas chromatography-mass spectrometry (GC-MS) analysis also revealed the presence of momilactone A and B, phenols, phenolic acids, and long-chain fatty acids. Salanti (2010) investigated the chemical constituents of rice husk. The study indicated that rice husk lignin is composed of guaiacyl and p-hydroxyphenyl units. The acidolysis method yielded a substantially high lignin recovery with a favorable degree of purity, whereas the alkaline enzymatic lignin samples were found to be rich in polysaccharide residues and oxidized functional groups.

Rice husk also exhibits antimicrobial activity. The samples are dried at 100 °C for 2 hours, combined with 10% methanol (MeOH), produced the most potent antimicrobial activity against *Escherichia coli, Klebsiella pneumoniae, Listeria monocytogenes, Bacillus subtilis, and Proteus mirabilis* (Minh et al., 2018). Antimicrobial activity was also observed against *Staphylococcus aureus.* Furthermore, biofilms produced by both methicillin-resistant *S. aureus* (MRSA) and methicillin-sensitive strains were observed to undergo significant inhibition. Conversely, this extract demonstrated no activity during the degradation phase. This indicates the potential of rice husk to be developed not only as an antimicrobial agent but also as a prospective antibiofilm agent (Burlacchini et al., 2024). Liquid smoke derived from rice husk also exerts antibacterial and preservative properties. The liquid smoke was synthesized via rice husk pyrolysis at 300°C, 350°C, and 400°C. Following purification through distillation, the liquid smoke was processed into powder using the freeze-drying method. GC-MS analysis revealed that rice husk liquid smoke contains various chemical compounds, including acetic acid, 2-propanone, butanal, propanoic acid, 2-cyclopentene, and phenolic compounds. The liquid smoke powder successfully inhibited the growth of all tested bacteria, yielding varying zones of inhibition (6–9 mm). These findings indicate that rice husk liquid smoke powder can be used as a natural alternative to synthetic food preservatives (Muriady et al., 2022).

In addition to its antimicrobial and antioxidant properties, rice husk demonstrates the potential for development as a mitogenic and antiproliferative agent. This investigation was conducted using 70% ethanolic extracts of rice husks from nine rice cultivars in Korea. The rice husk extract of the Seolgaeng cultivar exhibited antiproliferative activity against cancer cell lines (MCF7 and NCI-H460), whereas the extract of the Hongjinju cultivar demonstrated significant mitogenic activity (Kim et al., 2011).

CONCLUSION

The Top commodities of Banyumas Regency, along with their agricultural by-products, demonstrate bioactive compound profiles that provide exceptional therapeutic potential, extending far beyond their basic nutritional value. Many scientific evidence affirms that the holistic exploration of local commodities, including the optimal utilization of previously neglected plant parts, can yield significant and strategic pharmacological agents. These therapeutic properties are antioxidant, antimicrobial, anti-inflammatory, and metabolic therapy-related functions. Optimizing this local potential comodity not only offers a concrete solution to mitigate Indonesia's reliance on imported pharmaceutical raw materials and the limited availability of wild-sourced medicinal ingredients, but also acts as a catalyst for implementing a sustainable circular economy; an approach capable of simultaneously elevating regional economic value and broadly advancing public health.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Abdul Aziz, A. H., Rizkiyah, D. N., Qomariyah, L., Irianto, I., Che Yunus, M. A., & Putra, N. R. (2023). Unlocking the Full Potential of Clove (Syzygium aromaticum) Spice: An Overview of Extraction Techniques, Bioactivity, and Future Opportunities in the Food and Beverage Industry. *Processes*, *11*(8), 2453. https://doi.org/10.3390/pr11082453

Akinpelu, D. A., & Obuotor, E. M. (2000). Antibacterial activity of *Nicotiana tabacum* leaves. *Fitoterapia*, *71*(2), 199–200. https://doi.org/10.1016/S0367-326X(99)00148-3

Al-Lahham, S., Sbieh, R., Jaradat, N., Almasri, M., Mosa, A., Hamayel, A., & Hammad, F. (2020). Antioxidant, antimicrobial and cytotoxic properties of four different extracts derived from the roots of *Nicotiana tabacum L. European Journal of Integrative Medicine*, *33*, 101039. https://doi.org/10.1016/j.eujim.2019.101039

Amalia, F. F. (2020). Aktivitas Antibakteri Kopi Robusta Dalam Mempercepat Kejadian Penyembuhan Luka Pada Ulkus Diabetikum. *Healthy Tadulako Journal (Jurnal Kesehatan Tadulako)*, *6*(1), 1–6. https://doi.org/10.22487/htj.v6i1.95

Ameya, G., Manilal, A., & Merdekios, B. (2017). In vitro Antibacterial Activity and Phytochemical Analysis of Nicotiana tabacum L. Extracted in Different Organic Solvents. *The Open Microbiology Journal*, *11*, 352–359. https://doi.org/10.2174/1874285801711010352

Antunes, F., Mota, I. F., Fangueiro, J. F., Lopes, G., Pintado, M., & Costa, P. S. (2023). From sugarcane to skin: Lignin as a multifunctional ingredient for cosmetic application. *International Journal of Biological Macromolecules*, *234*, 123592. https://doi.org/10.1016/j.ijbiomac.2023.123592

Araújo, T. S. L., Costa, D. S., Sousa, N. A., Souza, L. K. M., de Araújo, S., Oliveira, A. P., Sousa, F. B. M., Silva, D. A., Barbosa, A. L. R., Leite, J. R. S. A., & Medeiros, J. V. R. (2015). Antidiarrheal activity of cashew GUM, a complex heteropolysaccharide extracted from exudate of *Anacardium occidentale* L. in rodents. *Journal of Ethnopharmacology*, *174*, 299–307. https://doi.org/10.1016/j.jep.2015.08.020

Arif, H. S., Arifah Sri Wahyuni, M. S., & Dr. Haryoto, M. S. (2013). *Potensi Biolarvasida Ekstrak Etanol Kulit Batang Karet India (Ficus elastica Nois Ex Blume) Dan Uji Toksisitasnya Dengan Metode Brine Shrimps Lethality Test* [S1, Universitas Muhammadiyah Surakarta]. https://eprints.ums.ac.id/24187/

Badan Pusat Statistik Kabupaten Banyumas,. (2025). *Statistik Daerah Kabupaten Banyumas 2025* . (Vol. 15). (Original work published Badan Pusat Statistik Kabupaten Banyumas)

Badan Pusat Statistik Kabupaten Banyumas. (2026). *Kabupaten Banyumas Dalam Angka 2026. Vol. 51. Purwokerto: BPS Kabupaten Banyumas, 2026. ISSN 0215-4331. No. Publikasi 33020.26003.*

Banyumas, B. P. S. K. (2025). *Produksi Perkebunan Rakyat Menurut Jenis Tanaman di Kabupaten Banyumas (ribu ton), 2025—Tabel Statistik*. https://banyumaskab.bps.go.id/id/statistics-table/3/Y0hOWWFGZHpPVkpUVjFKUlowVjBhMUI1Wm1aWFp6MDkjMw==/produksi-perkebunan-rakyat-menurut-jenis-tanaman-di-kabupaten-banyumas--ribu-ton---2022.html

BPOM. (2022). *Siaran Pers | Badan Pengawas Obat dan Makanan*. https://www.pom.go.id

Buamard, N., & Benjakul, S. (2017). Ethanolic coconut husk extract: In vitro antioxidative activity and effect on oxidative stability of shrimp oil emulsion. *European Journal of Lipid Science and Technology*, *119*(11), 1700131. https://doi.org/10.1002/ejlt.201700131

Burlacchini, G., Sandri, A., Papetti, A., Frosi, I., Boschi, F., Lleo, M. M., & Signoretto, C. (2024). Evaluation of Antibacterial and Antibiofilm Activity of Rice Husk Extract against Staphylococcus aureus. *Pathogens*, *13*(1), 80. https://doi.org/10.3390/pathogens13010080

Cortés-Rojas, D. F., de Souza, C. R. F., & Oliveira, W. P. (2014). Clove (Syzygium aromaticum): A precious spice. *Asian Pacific Journal of Tropical Biomedicine*, *4*(2), 90–96. https://doi.org/10.1016/S2221-1691(14)60215-X

Cyriac, M. B. (2013). Antimicrobial properties of coconut husk aqueous...: Archives of Medicine and Health Sciences. *Ovid*. https://doi.org/DOI:%2010.4103/2321-4848.123024

de Carvalho Melo-Cavalcante, A. A., de Moura Dantas, S. M. M., de Sousa Leite, A., Matos, L. A., de Castro e Sousa, J. M., Picada, J. N., & da Silva, J. (2011). In vivo Antigenotoxic and Anticlastogenic Effects of Fresh and Processed Cashew (Anacardium occidentale) Apple Juices. *Journal of Medicinal Food*, *14*(7–8), 792–798. https://doi.org/10.1089/jmf.2010.0153

de Lima, A. C. S., Soares, D. J., da Silva, L. M. R., de Figueiredo, R. W., de Sousa, P. H. M., & de Abreu Menezes, E. (2014). *In vitro* bioaccessibility of copper, iron, zinc and antioxidant compounds of whole cashew apple juice and cashew apple fibre (*Anacardium occidentale* L.) following simulated gastro-intestinal digestion. *Food Chemistry*, *161*, 142–147. https://doi.org/10.1016/j.foodchem.2014.03.123

Dewajanti, A. M. (2019). Peranan Asam Klorogenat Tanaman Kopi Terhadap Penurunan Kadar Asam Urat dan Beban Oksidatif. *Jurnal Kedokteran Meditek*, *25*(1), 46–51. https://doi.org/10.36452/jkdoktmeditek.v25i1.1758

Dharmawan, B. (2025). *Developing the agricultural commodities on regional scale: An initiative corporation at development area districts in Central Java, Indonesia—IOPscience*. https://iopscience.iop.org/article/10.1088/1755-1315/1518/1/012010/meta

Fauzaan, A. R. (2022). *Uji AKtivitas Inhibisi Alfa-Glukosidase dari Beberapa Tumbuhan Daun Genius Ficus (Ficus spp.)* [Other, Universitas Bhakti Kencana]. https://repository.bku.ac.id/id/eprint/2627/

Gao, X.-M., Hu, Q.-F., Yang, G., Li, X., Yang, X., Mu, H., & Chen, Y. (2012). Lignan Derivatives from the Leaves Nicotiana tabacum and Their Activities. *HETEROCYCLES*, *85*(1), 147. https://doi.org/10.3987/COM-11-12349

Ginting, C. N., Lister, I. N. E., Girsang, E., Riastawati, D., Kusuma, H. S. W., & Widowati, W. (2020). Antioxidant Activities of Ficus elastica Leaves Ethanol Extract and Its Compounds. *Molecular and Cellular Biomedical Sciences*, *4*(1), 27–33. https://doi.org/10.21705/mcbs.v4i1.86

Gordon, A., Friedrich, M., Matta, V. M. da, Moura, C. F. H., & Marx, F. (2012). Changes in phenolic composition, ascorbic acid andantioxidant capacity in cashew apple (Anacardium occidentale L.)during ripening. *Fruits*, *67*(4), 267–276. https://doi.org/10.1051/fruits/2012023

Guedes, D., Martins, G., Alviano, D. S., Lutterbach, M. T. S., Reznik, L. Y., & Sérvulo, E. F. C. (2018). *Coconut Husk Fiber Proanthocyanidins: Ecofriendly Corrosion Inhibitor, Ecotoxicity and Biocide Activity*. *8*(2).

Gutiérrez-Paz, C., Rodríguez-Moreno, M.-C., Hernández-Gómez, M.-S., & Fernández-Trujillo, J. P. (2024). The Cashew Pseudofruit (Anacardium occidentale): Composition, Processing Effects on Bioactive Compounds and Potential Benefits for Human Health. *Foods*, *13*(15), 2357. https://doi.org/10.3390/foods13152357

Handayani, S. (2020). *Uji Aktivitas Antioksidan Ekstrak Daun Karet Kebo (Ficus Elastica) dengan Metode Peredaman Radikal Bebas Dpph (1,1-Diphenyl-2-Picrylhydrazil)* \|. https://bestjournal.untad.ac.id/index.php/Galenika/article/view/15022

Haro-González, J. N., Castillo-Herrera, G. A., Martínez-Velázquez, M., & Espinosa-Andrews, H. (2021). Clove Essential Oil (Syzygium aromaticum L. Myrtaceae): Extraction, Chemical Composition, Food Applications, and Essential Bioactivity for Human Health. *Molecules*, *26*(21), 6387. https://doi.org/10.3390/molecules26216387

Hasyim, A., Suhaenah, A., & Tahir, M. (2023). Uji Aktivitas Antioksidan Fraksi Etil Asetat Daun Karet Kebo (Ficus elastica) Dengan Menggunakan Metode FRAP. *Makassar Pharmaceutical Science Journal (MPSJ)*, *1*(3), 142–149. https://doi.org/10.33096/mpsj.v1i3.76

Huang, Q., Wen, T., Fang, T., Lao, H., Zhou, X., Wei, T., Luo, Y., Xie, C., Huang, Z., & Li, K. (2025). A comparative evaluation of the composition and antioxidant activity of free and bound polyphenols in sugarcane tips. *Food Chemistry*, *463*, 141510. https://doi.org/10.1016/j.foodchem.2024.141510

Iqbal, Z., Lateef, M., Jabbar, A., Ghayur, M. N., & Gilani, A. H. (2006). In vitro and In vivo anthelmintic activity of Nicotiana tabacum L. leaves against gastrointestinal nematodes of sheep. *Phytotherapy Research*, *20*(1), 46–48. https://doi.org/10.1002/ptr.1800

Irondi, E. A., Shode, F. O., Afolabi, W. O., & Boligon, A. A. (2017). In Vitro Inhibitory Effects of Coconut Husk Extract on Some Enzymes Relevant to the Pathogenesis of Obesity, Gout and Hypertension. *Journal of Biologically Active Products from Nature*, *7*(5), 358–368. https://doi.org/10.1080/22311866.2017.1395297

Ismat, I., & Saputri, A. I. (2026). *Buku Ajar Farmakologi Bahan Alam*. CV Eureka Media Aksara.

Jose, M., Cyriac, M. B., Pai, V., Varghese, I., & Shantaram, M. (2014). Antimicrobial properties of Cocos nucifera (coconut) husk: An extrapolation to oral health. *Journal of Natural Science, Biology, and Medicine*, *5*(2), 359–364. https://doi.org/10.4103/0976-9668.136184

Kaewbutra, S., Wattanathorn, J., Thukham-mee, W., Muchimapura, S., & Tong-Un, T. (2016). *Cashew Apple Juice Improves Physical Fitness and Oxidative Stress Status in the Middle-Aged and Elderly Volunteers*. *99*.

Kailaku, S., Syakir, M., Mulyawanti, I., & Syah, A. (2017). Antimicrobial activity of coconut shell liquid smoke. *IOP Conference Series: Materials Science and Engineering*, *206*(1), 012050. https://doi.org/10.1088/1757-899X/206/1/012050

Khuan, C.-H. (2025). *Rice Bran Extract Alleviates Inflammation and Promotes Wound Healing in Radiation Dermatitis—Kuan—2025—Experimental Dermatology—Wiley Online Library*. https://onlinelibrary.wiley.com/doi/epdf/10.1111/exd.70162

Kim, D.-J., Oh, S.-K., Chun, A., Yoon, M.-R., Hong, H.-C., Choi, I.-S., Lee, J.-S., Yu, K.-W., & Kim, Y.-K. (2011). Evaluation of Biological Activities of Rice Husk Extracts. *Journal of Food Science and Nutrition*, *16*(2), 179–183.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, *127*, 221–232. https://doi.org/10.1016/j.resconrec.2017.09.005

Li, K., Han, Y., Wang, Y., Zhang, C., Liu, W., Xi, Y., Zhou, Y., Li, L., & Li, H. (2025). Urate-lowering and renal-protective effects of sugarcane polyphenols in hyperuricemia: Mechanisms and key components. *Food & Function*, *16*(17), 6760–6772. https://doi.org/10.1039/d5fo00508f

Li, N., Jiang, H., Yang, J., Wang, C., Wu, L., Hao, Y., & Liu, Y. (2021). Characterization of phenolic compounds and anti-acetylcholinase activity of coconut shells. *Food Bioscience*, *42*, 101204. https://doi.org/10.1016/j.fbio.2021.101204

Malik, R., Bokhari, T., Siddiqui, M., Younis, U., Hussain, M., & Khan, I. (2015). Antimicrobial activity of Nerium oleander L. and Nicotiana tabacum L.: A comparative study. *Pakistan Journal of Botany*, *47*, 1587–1592.

Maulana, R. (2019). *Penentuan Kadar Total Fenolik dan Flavonoid Ekstrak MEtanol Daun Karet Kebo (ficus Elastica L.)* [Sarjana, STIKes BTH Tasikmalaya]. https://repository.universitas-bth.ac.id/185/

Mazaya, G., Karseno, K., & Yanto, T. (2020). Antimicrobial and Phytochemical Activity of Coconut Shell Extracts. *Turkish Journal of Agriculture - Food Science and Technology*, *8*(5), 1090–1097. https://doi.org/10.24925/turjaf.v8i5.1090-1097.3282

Meneguelli, T. S. (2024). *Cashew nut (Anacardium occidentale L.) and cashew nut oil reduce cardiovascular risk factors in adults on weight-loss treatment: A randomized controlled three-arm trial (Brazilian Nuts Study)*. *11*. https://doi.org/doi:%2010.3389/fnut.2024.1407028

Minh, T. N., Xuan, T. D., Ahmad, A., Elzaawely, A. A., Teschke, R., & Van, T. M. (2018). Efficacy from Different Extractions for Chemical Profile and Biological Activities of Rice Husk. *Sustainability*, *10*(5), 1356. https://doi.org/10.3390/su10051356

Mozammel, H. M., Masahiro, O., & Sc, B. (2002). Activated charcoal from coconut shell using ZnCl2 activation. *Biomass and Bioenergy*, *22*(5), 397–400. https://doi.org/10.1016/S0961-9534(02)00015-6

Muriady, Meilina, H., & Faisal, M. (2022). Antibacterial Activity of Liquid Smoke Powder from Rice Husk. *GEOMATE Journal*, *23*(95), 89–96.

Naomi, L., elisma, elisma, & Yuliawati, Y. (2023). Uji Efektifitas Antipiretik Ekstrak Etanol Kulit Buah Kopi Arabika (Coffea arabica L.) Terhadap Mencit Putih Jantan. *Indonesian Journal of Pharma Science*. https://repository.unja.ac.id/57120/

Nidyatama, S. P., & Wahyuniari, I. A. I. (2026). Potensi Bengkuang (Pachyrhizus erosus) sebagai Sumber Antioksidan Alami dalam Pencegahan Penuaan Kulit. *Journal of Syntax Literate*, *11*(2), 1693.

Okokon, J. E., Mobley, R., Edem, U. A., Bassey, A. I., Fadayomi, I., Drijfhout, F., Horrocks, P., & Li, W.-W. (2022). In vitro and in vivo antimalarial activity and chemical profiling of sugarcane leaves. *Scientific Reports*, *12*(1), 10250. https://doi.org/10.1038/s41598-022-14391-8

Olatunde, O. O., Benjakul, S., & Vongkamjan, K. (2019). Coconut husk extract: Antibacterial properties and its application for shelf-life extension of Asian sea bass slices. *International Journal of Food Science and Technology*, *54*(3), 810–822. https://doi.org/10.1111/ijfs.14000

Pradana, R. (2022). *Uji Efek Antipiretik Infusa Daun kopi Arabika (coffea arabica L.) Terhadap Mencit Putih Jantan* [Other, UNIVERSITAS JAMBI]. https://repository.unja.ac.id/

Pusat Informasi Perubahan Iklim BMKG. (2022). *Peta Rata-Rata Curah Hujan dan Hari Hujan Periode 1991–2020 Indonesia. Jakarta: Pusat Informasi Perubahan Iklim, Badan Meteorologi Klimatologi dan Geofisika.*

Putri, A. N. A. (2020). *Uji Aktivitas Antiplatelet Ekstrak Air dan Etanol Daun Karet Kebo (Ficus elastica Roxb.ex Hornem) secara In Vitro* [Universitas Gadjah Mada]. https://etd.repository.ugm.ac.id/penelitian/detail/184664

Putri, D. A., & Fatmawati, S. (2019). A New Flavanone as a Potent Antioxidant Isolated from Chromolaena odorata L. Leaves. *Evidence-Based Complementary and Alternative Medicine*, *2019*(1), 1453612. https://doi.org/10.1155/2019/1453612

Putri, L. N., Arifah Sri Wahyuni, M. S., & Dr. Haryoto, M. S. (2013). *Uji Aktivitas Larvasida Fraksi Etil Asetat Ekstrak Etanol Kulit Batang Karet India (Ficus elastica Nois ex Blume) Serta Skrining Fitokimianya* [S1, Universitas Muhammadiyah Surakarta]. https://eprints.ums.ac.id/24188/

Rodiah, M. H. (2018). *Antioxidant Activity of Natural Pigment from Husk of Coconut. | EBSCOhost*. https://openurl.ebsco.com/EPDB%3Agcd%3A15%3A17069631/detailv2?sid=ebsco%3Aplink%3Acrawler-gcd&id=ebsco%3Agcd%3A128402702&crl=c&jrnl=15113701&link_origin=scholar.google.com

Rusdi, R., Hasanuddin, A., Mulyati, M., & Fatmawati, F. (2022). Effect of coconut husk extract on broiler chicken performance, pH and microbial composition of digesta, and small intestine histomorphology. *Journal of the Indonesian Tropical Animal Agriculture*, *47*(2), 119–127. https://doi.org/10.14710/jitaa.47.2.119-127

Salanti, A., Zoia, L., Orlandi, M., Zanini, F., & Elegir, G. (2010). *Structural Characterization and Antioxidant Activity Evaluation of Lignins from Rice Husk*. https://doi.org/https://doi.org/10.1021/jf102188k

Schmier, S., Hosoda, N., & Speck, T. (2020). Hierarchical Structure of the Cocos nucifera (Coconut) Endocarp: Functional Morphology and its Influence on Fracture Toughness. *Molecules*, *25*, 223. https://doi.org/10.3390/molecules25010223

Schorderet Weber, S., Kaminski, K. P., Perret, J.-L., Leroy, P., Mazurov, A., Peitsch, M. C., Ivanov, N. V., & Hoeng, J. (2019). Antiparasitic properties of leaf extracts derived from selected *Nicotiana* species and *Nicotiana tabacum* varieties. *Food and Chemical Toxicology*, *132*, 110660. https://doi.org/10.1016/j.fct.2019.110660

Shiyan, S., Herlina, H., Arsela, D., & Latifa, E. (2017). Aktivitas Antidiabetes Ekstrak Etanolik Daun Kopi Robusta (Coffea canephora) Pada Tikus Diabetes Tipe 2 yang Diberi Diet Lemak Tinggi dan Sukrosa. *Jurnal Farmasi Sains Dan Praktis*, *3*(2), 39–46. https://doi.org/10.31603/pharmacy.v3i2.1730

Simamora, Y., Fachrial, E., & Syahputra, H. D. (2026). Aktivitas Antioksidan dan Inhibitor Enzim Tirosinase Ekstrak Daun Pepaya (Carica papaya L.). *Herbal Medicine Journal*, *9*(1), 58–66. https://doi.org/10.58996/hmj.v9i1.212

Siregar, M. U., Lubis, A. A., & Syahputra, H. D. (2026). Uji Efektivitas Nefroprotektif Ekstrak Buah Kopi (Coffea Arabica L) Terhadap Perubahan Morfologi Ginjal dan Tumor Necrosis Factor-Alpha (TNF- α) pada Tikus yang Diinduksi Gentamisin. *Journal of Pharmaceutical and Sciences*, 1782–1790. https://doi.org/10.36490/journal-jps.com.v9i2.1424

Sousa, J. M. S., de Abreu, F. A. P., Ruiz, A. L. T. G., da Silva, G. G., Machado, S. L., Garcia, C. P. G., Filho, F. O., Wurlitzer, N. J., de Figueiredo, E. A. T., Magalhães, F. E. A., Muniz, C. R., Zocolo, G. J., & Dionísio, A. P. (2021). Cashew apple (Anacardium occidentale L.) extract from a by-product of juice processing: Assessment of its toxicity, antiproliferative and antimicrobial activities. *Journal of Food Science and Technology*, *58*(2), 764–776. https://doi.org/10.1007/s13197-020-04594-0

Sruthi, P., Roopavathi, C., & Madhava Naidu, M. (2023). Profiling of phenolics in cashew nut (*Anacardium occidentale* L.) testa and evaluation of their antioxidant and antimicrobial properties. *Food Bioscience*, *51*, 102246. https://doi.org/10.1016/j.fbio.2022.102246

Tang, C., Carrera Montoya, J., Fritzlar, S., Flavel, M., Londrigan, S. L., & Mackenzie, J. M. (2024). Polyphenol rich sugarcane extract (PRSE) has potential antiviral activity against influenza A virus in vitro. *Virology*, *590*, 109969. https://doi.org/10.1016/j.virol.2023.109969

Tarawan, V. M., Mantilidewi, K. I., Dhini, I. M., Radhiyanti, P. T., & Sutedja, E. (2017). Coconut Shell Liquid Smoke Promotes Burn Wound Healing. *Journal of Evidence-Based Complementary & Alternative Medicine*, *22*(3), 436–440. https://doi.org/10.1177/2156587216674313

Trox, J. (2010). *Bioactive Compounds in Cashew Nut (Anacardium occidentale L.) Kernels: Effect of Different Shelling Methods*. *58*. https://pubs.acs.org/jafcau/article-abstract/58/9/5341/208432/Bioactive-Compounds-in-Cashew-Nut-Anacardium?redirectedFrom=fulltext

Valadez-Carmona, L., Cortez-García, R. M., Plazola-Jacinto, C. P., Necoechea-Mondragón, H., & Ortiz-Moreno, A. (2016). Effect of microwave drying and oven drying on the water activity, color, phenolic compounds content and antioxidant activity of coconut husk (Cocos nucifera L.). *Journal of Food Science and Technology*, *53*(9), 3495–3501. https://doi.org/10.1007/s13197-016-2324-7

Victor, E., & Jeroh, E., (2012). *Anti diabetic effects of the cocos nucifera (coconut) husk extract*. *4*. https://www.cenresinjournals.com/wp-content/uploads/2020/03/Page-16-25899.pdf

Wanyo, P., Meeso, N., & Siriamornpun, S. (2014). Effects of different treatments on the antioxidant properties and phenolic compounds of rice bran and rice husk. *Food Chemistry*, *157*, 457–463. https://doi.org/10.1016/j.foodchem.2014.02.061

Wardana, L. D., Arifah Sri Wahyuni, M. S., & Dr. Haryoto, M. S. (2013). *Uji Bioaktivitas Fraksi N-Heksan Ekstrak Etanol Kulit Batang Karet India (Ficus elastica Nois Ex Blume) Terhadap Larva* [S1, Universitas Muhammadiyah Surakarta]. https://eprints.ums.ac.id/22783/

Wardani, S. P. W., Arifah Sri Wahyuni, M. S., & Dr. Haryoto, M. S. (2013). *Uji Biolarvasida Fraksi Etanol Kulit Batangkaret India (Ficus elastica Nois ex Blume) Terhadap Larva Nyamuk Anopheles aconitus Dan Aedes aegypti Serta Skrining Fitokimia* [S1, Universitas Muhammadiyah Surakarta]. https://eprints.ums.ac.id/26212/

Wenas, D., Aliya, L., & Janah, N. (2020). Aktivitas Antiinflamasi Ekstrak Etanol Daun Kopi Arabika (Coffea Arabica L.) Pada Edema Tikus. *Buletin Penelitian Tanaman Rempah Dan Obat*, *31*, 75. https://doi.org/10.21082/bullittro.v31n2.2020.75-84

Widianingsih, M. (2025). Daun dan Kulit Buah Kopi Robusta (Coffea canephora Pierre ex A.Froehner) Sebagai Sumber Senyawa Bioaktif untuk Aplikasi Farmakologi. *Borneo Journal of Biology Education (BJBE)*, *7*(2), 140–148. https://doi.org/10.35334/fp1sg371

Xue, Q., Xiang, Z., Wang, S., Cong, Z., Gao, P., & Liu, X. (2022). Recent advances in nutritional composition, phytochemistry, bioactive, and potential applications of Syzygium aromaticum L. (Myrtaceae). *Frontiers in Nutrition*, *9*, 1002147. https://doi.org/10.3389/fnut.2022.1002147

Yani, I. A., Suhaenah, A., & Aminah, A. (2024). Antioxidant activity Uji aktivitas antioksidan ekstrak daun karet kebo (Ficus elastica) dengan menggunakan metode maserasi bertingkat. *Makassar Pharmaceutical Science Journal (MPSJ)*, *2*(3), 450–460. https://doi.org/10.33096/mpsj.v2i3.283

Zharif, M. R., Assari, A. V., Aqilah, I. N., Iqbal, M., Afifah, A. F. N., Syafiq, M. A., Terate, M. W., Serenita, A., Jati, H. N., & Ivanaomi, R. (2024). *Pengembangan Ekonomi Kreatif: Pemanfaatan Limbah sebagai Produk Bernilai Jual Tinggi dan Pemasaran Berkelanjutan*.

Ziroldo, J. C., Torres, L. M. B., & Gamberini, M. T. (2024). Sugarcane (*Saccharum officinarum* L.) induces psychostimulant, anxiolytic-like effects and improvement of motor performance in rats. *Journal of Ethnopharmacology*, *333*, 118476. https://doi.org/10.1016/j.jep.2024.118476

Zou, X., BK, A., Rauf, A., Saeed, M., Al-Awthan, Y. S., A. Al-Duais, M., Bahattab, O., Hamayoon Khan, M., & Suleria, H. A. R. (2021). Screening of Polyphenols in Tobacco (Nicotiana tabacum) and Determination of Their Antioxidant Activity in Different Tobacco Varieties. *ACS Omega*, *6*(39), 25361–25371. https://doi.org/10.1021/acsomega.1c03275

Zukhri, S., & Nurhaini, R. (2019). Uji Efektivitas Antibakteri Ekstrak Etanol Daun Karet Kerbau (Ficus elastica Roxb. Ex Hornem.) Terhadap Bakteri Staphylococcus aureus. *MOTORIK Jurnal Ilmu Kesehatan*, *14*(1), 58–70. https://doi.org/10.61902/motorik.v14i1.23

Zuraida, I., Sukarno, S., & Budijanto, S. (2011). Antibacterial activity of coconut shell liquid smoke (CS-LS) and its application on fish ball preservation. *International Food Research Journal*, *18*, 405–410.