
Local Potential of Kabau (*Archidendron bubalinum* (Jack) I.C Nielsen): A Comprehensive Literature of Traditional Uses, Phytochemistry, Pharmacology and Learning Resources Potential

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Abstrak

Kabau (*Archidendron bubalinum* (Jack) I.C. Nielsen) is a lesser-known legume native to Sumatra and surrounding regions that is widely used as food and traditional medicine, but its scientific and educational potential remains underexplored. This study presents a qualitative–descriptive literature review synthesizing ethnobotanical, phytochemical, pharmacological, and educational evidence on kabau, based on peer-reviewed national and international publications indexed in databases such as Scopus, PubMed, SpringerLink, Wiley Online Library, and Google Scholar. The review shows that kabau seeds and fruit pods contain diverse secondary metabolites, dominated by phenolics, flavonoids, terpenoids, fatty acids (e.g., linoleic and palmitic acids), and sulfur-containing amino acids related to djenkolic acid. These constituents underpin strong *in vitro* antioxidant activity and support preliminary evidence of antidiabetic, anti-hyperuricemic, and antimicrobial effects in enzyme-based assays and animal models. Ethnobotanical data from Bengkulu and other regions document kabau as a functional food, a remedy for metabolic and digestive disorders, and a component of local cultural identity. Drawing on this evidence, the article proposes a framework for integrating kabau into biology education as a contextual learning resource across topics such as plant morphology, ecology, ethnobotany, phytochemistry, health, and STEM-based inquiry. Integrating local biological resources like kabau is argued to promote scientific literacy, critical thinking, and sustainability awareness while strengthening students’ appreciation of local biodiversity. Further field, experimental, and design-based research is needed to standardize kabau-derived products and to evaluate their effectiveness and safety, as well as their impact on learning outcomes in science education.

Keywords: *Archidendron bubalinum*, Ethnobotany, Learning Resources Potential, Phytochemistry, Traditional Uses

INTRODUCTION

For decades, several studies have examined and documented how humans utilize all the potential of nature, especially plants for medicinal uses. It is estimated that more than 80,000 of total plant species have been identified and used as medicinal plants around the world (Petrovska, 2012). The humans initial interest in plants began with their need for food, shelter, protection, and later his attention turned to remedies for wounds and diseases (Rahman et al., 2019). Through the rapidly growing knowledge of ethnobotany, the potential of each plant species to provide for human needs is increasingly being explored, especially its usefulness in the study of traditional medicine (Ramirez, 2007).

The evergreen plant *Archidendron bubalinum* (Jack) I.C Nielsen was known as an indigenous plant with enormous potential spread across Sumatra in Indonesia, including province of Bengkulu, Malaysia and Thailand. Kabau (*A. bubalinum*) has different local names such as julang-jaling (Lampung), jering utan (Riau), jering kabau (West Sumatra), kabau (Jambi, Palembang, Riau), kabau or kabau (Bengkulu), kerdas or jering tupai (Malaysia), and nieng-no (Thailand) (Fanisah et al., 2023; Fitria Ningrum et al., 2021; Lim, 2012; Suwardi et al., 2023). This plant is included in the Mimosaceae family but also belongs to the Fabaceae or Leguminosae (Nielsen, 1992). These species grow in a friendly manner in tropical rainforests found in the midst of rain forests and hills.

A. bubalinum produces a fruit with seeds that smell sharply like jengkol, and is used in dishes similar to jengkol (*Archidendron jiringa*) or petai (*Parkia speciosa* Hassk). This species have the flavor of jering and are similarly used to flavor food. *A. bubalinum* has pods that are smaller than jengkol, oval-shaped and green in color with tightly arranged seeds inside. The flavor and aroma of kabau seeds are stronger than jengkol seeds (Ong, 2015).

In Bengkulu and almost all parts of Sumatra, *A. bubalinum* fruit is used as a side dish and appetite-enhancing vegetables, just like jengkol and petai. So far, people have only known *A. bubalinum* fruit as fresh vegetables or dietary supplements, and its wood as construction materials and domestic appliances, although kabau plants are utilized as traditional remedies in numerous parts of Indonesia and Malaysia, including antibacterial (Irawan et al.,

2018), antifungal, antioxidant (Liyana et al., 2019; Teh et al., 2022), anti-diabetes (Hanafi et al., 2018), anti-uric acid (Styani et al., 2018), stomach pain treatment, and fever (Silalahi, 2015).

Although *A. bubalinum* has begun to be widely researched regarding its chemical content and bioactivity, there has been no comprehensive review of this edible medicinal plant. Therefore, this article intends to provide a systematic overview of *A. bubalinum* that includes ethnobotanical information, traditional uses, phytochemicals, and specific information on the extent of its potential as a biology learning resource. It is hoped that this review can provide new insights for further research into the chemical content and bioactivity of *A. bubalinum* and the implications of its potential as a learning resource.

METHOD

This study employed a qualitative-descriptive literature review approach to explore and synthesize information regarding the ethnomedicinal uses, phytochemical constituents, pharmacological potential, and educational relevance of *Archidendron bubalinum* (Kabau). The information was collected through in-depth searches of relevant scientific publications, books, theses, and academic reports. Data sources were accessed through reputable scientific databases including Scopus, ScienceDirect, PubMed, SpringerLink, Wiley Online Library, and Google Scholar.

The selection of literature was guided by the use of specific keywords and combinations such as “*Archidendron bubalinum*”, “Kabau”, “ethnomedicinal uses”, “traditional medicine”, “phytochemical analysis”, “pharmacological activity”, “toxicity”, and “learning resources”. These keywords were used in English and occasionally in Indonesian, depending on the availability of relevant sources. Articles were included based on their relevance to at least one of the following aspects: (1) traditional use of Kabau by local communities; (2) identification and characterization of bioactive chemical compounds from various parts of the plant; (3) reported pharmacological effects such as antimicrobial, antioxidant, anti-inflammatory, or antidiabetic activity; and (4) the plant’s potential to be integrated into biology education as a contextual learning resource. Literature that lacked academic credibility, did not present

complete data, or focused on other *Archidendron* species not relevant to this study was excluded.

No strict time limitation was applied to the search, allowing the inclusion of both historical and contemporary sources, although greater emphasis was placed on recent studies published in the last two decades. The data collected were then grouped based on major themes—ethnobotany, phytochemistry, pharmacology, and educational potential. Each theme was analyzed descriptively and interpreted in relation to both scientific value and its relevance to biology learning in Indonesian educational contexts.

The use of Kabau as a learning resource was examined through references that discussed

and educational innovations involving local natural resources such as Kabau.

RESULTS AND DISCUSSION

a. Botany

Origin and Distribution

A. bubalinum is native to Sumatra Indonesia, Malaysia and Thailand. Primary and secondary rain forest, often emerging in regrowth; soil sandy loam or lateritic; altitude 0-100 (-900)m (Nielsen, 1992).

Plant Description

Small tree, rarely up to 20 m tall, trunk up to 25 cm long. Twigs small, rounded thoracic, red, glossy, light brown or reddish when dried, scaly with red-rusty hairs (Nielsen, 1992).

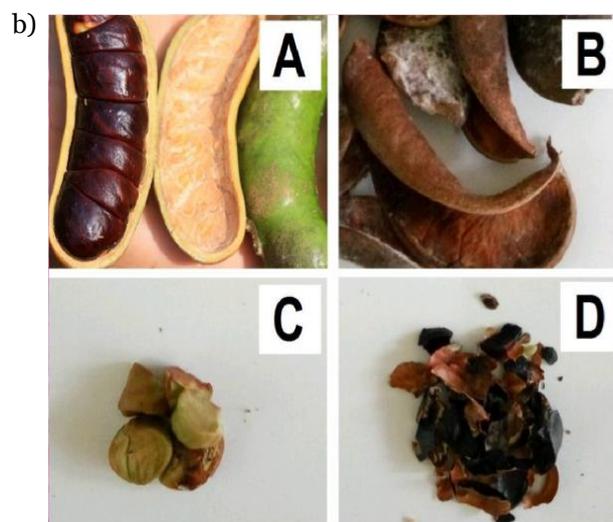
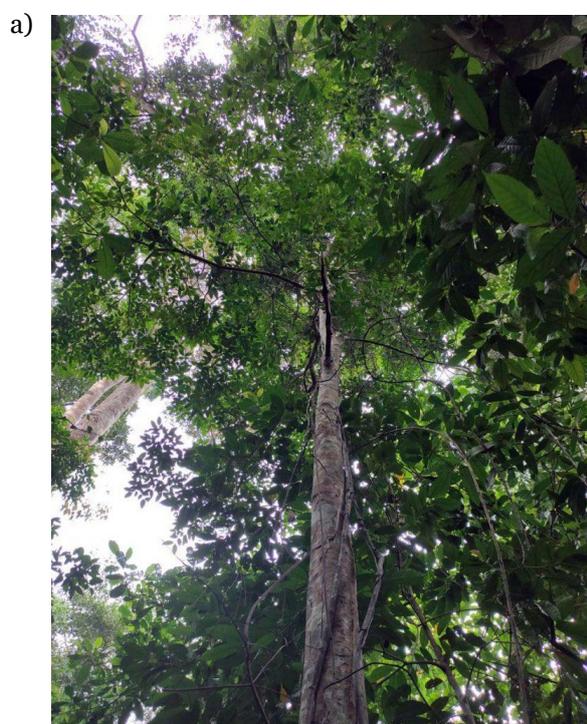


Figure 1. a) The kabau tree (*Archidendron bubalinum*) is a leguminous plant native to the rainforests of Sumatra (forest-ilm.iium.edu.my). b) Edible seeds with a strong sulfuric aroma, often consumed raw or cooked in traditional cuisine (Hanafi, 2018).

the integration of ethnobotanical knowledge into science education, including approaches such as contextual learning, problem-based learning, and STEM education. Relevant sources were also evaluated to determine how Kabau could be used to support the development of scientific literacy, local biodiversity awareness, and sustainable environmental education.

This literature review aims not only to summarize scientific findings but also to highlight the importance of *A. bubalinum* as a plant of high cultural, biological, and pedagogical value. The comprehensive insights provided are expected to support further studies

Multiple even-pinnate compound leaves, with a pair of leaflets (first degree fins), and 1-2(-3) pairs of leaflets opposite each fin. Petiole 0.5-4(-6) cm, locose, with one round nectar gland on the upper side near the tip. Leaflets asymmetrical at margins; lobed, ovate, to lanceolate, 5.5-16(-22) × 2.5-10.5 cm; paper-like to hirsute; lateral spinules about 7 pairs, strongly curved (Nielsen, 1992).

Inflorescence terminal or axillary at the distal leaves, rusty tomentose-puberulous, ± glabrescent, consisting of pedunculate glomerules aggregated into panicles to 20 cm long; glomerules composed of c. 5 sessile or

subsessile flowers; floral bracts triangular, acute, less than 1 mm, tomentose.

Flowers are seated or nearly seated, 5-numbered, white, and sweet-smelling. Petals are bell-shaped or broadly bowl-shaped, 1.5–2.5 mm. Corolla attached in a funnel-like shape, finely hairy, 2.5–5 mm. Stamens numerous, about 9 mm long; pistil.

Pods green or red, eventually yellowish with reddish inside; thoracic globose inflated to flattened, straight or slightly curved, 3.5–10 × 1.5–2.5 cm; rind woody, with fine, dense hairs or nearly glabrous, veins subtle, breaking up into seams on both sides.

Seeds are black, densely filling the fruit cavity; the central seeds are disc-like tablets, 8–15 mm high; the tip seeds are similar to trimmed tops (Nielsen, 1992).

Taxonomic Hierarchy

Taxonomic hierarchy is as follows:

- Kingdom : Plantae
- Division : Magnoliophyta
- Class : Magnoliopsida
- Order : Fabales
- Family : Fabaceae
- Subfamily : Mimosoideae
- Genus : Archidendron
- Species : *A. bubalinum* (Jack) I.C Nielsen

b. Phytochemistry

Several studies have previously reviewed some of the phytochemical content of *A. bubalinum* including alkaloids, flavonoids, terpenoids, tannins and polyphenols, etc (Hanafi et al., 2018; Irawan et al., 2018; Styani et al., 2018). Phytochemical studies on *Archidendron bubalinum* have revealed a complex profile of secondary metabolites distributed in different plant parts (seeds, seed shells, husks/pods, and associated endophytic fungi). Earlier reports only mentioned broad classes such as alkaloids, flavonoids, terpenoids, tannins, and polyphenols (Hanafi et al., 2018; Rahmawati et al., 2020; Styani et al., 2018), but more recent analytical work using GC–MS, LC–MS, and antioxidant-guided fractionation has clarified specific compound groups and their potential bioactivity.

Preliminary phytochemical screening of the husk (pod wall) and seed shells using methanol, ethanol, and ethyl acetate solvents consistently demonstrates the presence of flavonoids, terpenoids, phenolic compounds, and in some extracts alkaloids and saponins

(Hanafi et al., 2018; Rahmawati et al., 2020; Styani et al., 2018). LC–MS and GC–MS analyses of seed shells and husks have identified several fatty acids (e.g., linoleic acid, palmitic acid, stearic acid), simple phenolics, and other polar compounds that are associated with strong antioxidant activity (Irawan et al., 2018; Riasari et al., 2019; Rahmawati et al., 2020).

A detailed GC–MS study of the husk (“julang-jaling” husk) showed that *A. bubalinum* contains various volatile and semi-volatile constituents, including 9,12-octadecadienoic acid (linoleic acid), hexadecanoic acid (palmitic acid), and minor components such as 2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one and lenthionin (Irawan et al., 2018; Rahmawati et al., 2020). These compounds are widely recognized for antioxidant, hypocholesterolemic, anti-inflammatory, and antimicrobial properties, and thus contribute to the pharmacological potential of kabau as a functional food ingredient (Benzie & Strain, 1996; Sayuti & Yennina, 2015; Trilaksana, 2003).

Riasari et al. (2019) compared different extraction methods for seeds and seed shells (soxhlet vs. maceration) using ethanol and reported that total phenolic content and antioxidant activity varied among plant parts and origins (Lampung vs. South Sumatra). Seed shells generally exhibited higher total phenolic content and stronger DPPH scavenging activity than seed flesh, suggesting that the by-product fraction (seed coat) is a particularly rich source of phenolic antioxidants. Recent work by Rahmawati et al. (2020) using DPPH and FRAP assays further confirmed that 99.9% ethanol extract of kabau seed husk showed the strongest antioxidant capacity, with GC–MS revealing linoleic acid as the major constituent of the active fraction.

More recent phytochemical screening of kabau pods and seeds by Riana and co-workers also supports the dominance of phenolic and flavonoid constituents in ethanolic extracts, which correlate strongly with antioxidant parameters (Riana et al., 2024; Riana et al., 2025). These studies emphasize that extraction conditions (solvent polarity, temperature, and time) significantly influence the recovery of phenolics and the resulting antioxidant indices, reinforcing kabau’s potential as a source of natural antioxidants.

On the other hand, LC–MS analysis of the ethyl acetate fraction of seed shells demonstrated that this semi-polar extract is

dominated by terpenoids and flavonoids, with tannins, total phenols, saponins, and alkaloids not detected at significant levels (Styani et al., 2018). The same study detected candidate structures related to allopurinol and 2,4,7-trinitrofluorenone, which are thought to contribute to the observed xanthine oxidase inhibitory (anti-uric acid) activity (Styani et al., 2018). Beyond phenolics and terpenoids, members of the genus *Archidendron* are known to contain sulfur-containing amino acids, particularly djenkolic acid (L-djenkolate), which is responsible for the characteristic pungent odor and is associated with nephrotoxic effects

in related species such as *A. jiringa* (jengkol). Chemical profiling databases and chemosystematic studies indicate that djenkolic acid or closely related cysteine derivatives are also present in *A. bubalinum* (NP-MRD, 2022; PubChem, 2023; Flora Malesiana, 2011). These sulfur compounds explain both the strong aroma and the need for traditional processing (boiling, soaking, sprouting) to reduce potential toxicity, while the co-occurrence of high phenolic content offers a plausible biochemical basis for the plant's antioxidant and ethnomedicinal claims.

Table 1. Main phytochemical content of *Archidendron bubalinum*

Plant part / extract	Main compound classes / representative compounds	Method (assay)	Selected references
Husk (pod wall), methanol/ethanol	Flavonoids, terpenoids, phenolics; linoleic acid, palmitic acid, stearic acid, pyranone	Phytochemical test, GC-MS	Irawan et al., 2018; Rahmawati et al., 2020
Seed shell, ethanol (70–99.9%)	High total phenolics; strong DPPH scavenging; linoleic-acid-rich fraction	DPPH, FRAP, GC-MS	Riasari et al., 2019; Rahmawati et al., 2020
Seed shell, ethyl acetate	Terpenoids and flavonoids dominant; candidate allopurinol-like compound and 2,4,7-trinitrofluorenone	LC-MS, phytochemical screening	Styani et al., 2018
Seed flesh & husk, ethanol	Phenolics, flavonoids; low IC50 DPPH and FRAP (strong antioxidant)	DPPH, FRAP, GC-MS	Rahmawati et al., 2020; Riana et al., 2025
Pods/seeds (various origins)	Total phenolics and flavonoids vary with location and extraction method	TPC, TFC, DPPH	Riasari et al., 2019; Riana et al., 2024
Seeds (kernel)	Polyphenols with antibacterial, antifungal, and antioxidant activities	ORAC, FRAP, DPPH, TPC	Teh et al., 2022

In summary, the phytochemical profile of *A. bubalinum* (table 1) can be described as a combination of high phenolic-flavonoids (with strong antioxidant activity) and characteristic sulfur compounds (e.g., djenkolic acid) that contribute to its aroma and safety for consumption. This combination makes buffalo not only unique from a culinary and ethnobotanical perspective, but also attractive as a source of phytopharmaceutical raw materials

and contextual teaching materials in biology education

c. Traditional Uses

Archidendron bubalinum (locally known as "kabau") is a lesser-known legume species widely distributed in Southeast Asia, particularly in Sumatra (Indonesia), Malaysia, and Thailand. Across various regions in Sumatra, the plant is locally referred to by different names such as

“kabau” (Jambi, Palembang), “jering kabau” (West Sumatra), “kabeu” (Bengkulu), “julang-jaling” (Lampung), and “jering utan” (Riau) (Komariah & Hartana, 2016; Suwardi et al., 2023). Its pods produce large seeds with a strong sulfurous aroma, resembling *Parkia speciosa* (petai) and *Archidendron jiringa* (jengkol), making them a valuable aromatic ingredient in traditional dishes (Hanafi et al., 2018).

The edible parts commonly used are the seeds (both young and mature) and the young leaves. Mature seeds are typically roasted or ground and used as a condiment in spicy stews or curries, particularly in Padang and Malay-influenced dishes. In contrast, young, tender seeds are consumed raw as ulam (traditional vegetable salad) due to their crispy texture and slightly sweet flavor. Some communities also consume the sprouted seeds, locally referred to as “lahang,” to reduce the pungent smell. Additionally, the young leaves are used as raw vegetables because they share the same aromatic profile as the seeds (Komariah & Hartana, 2016; Adnan et al., 2023).

Aside from dietary uses, *A. bubalinum* plays a functional role in local ethnoveterinary and non-food utility practices. In West Sumatra, its foliage is used as livestock feed, while the tree’s sturdy wood is valued in traditional architecture for making canoe paddles, house posts, and other durable wooden tools (Suwardi et al., 2023).

From a medicinal perspective, the mature seeds are traditionally used as herbal remedies for type 2 diabetes. In Jambi and other parts of Sumatra, seeds are roasted, powdered, and consumed as a herbal infusion twice daily to help lower blood sugar levels. This local use is supported by broader ethnopharmacological evidence, where related species such as *A. jiringa* and *P. speciosa* have shown antihyperglycemic effects in animal models (Huda et al., 2021; Arullappan et al., 2022). Moreover, the bark decoction is reportedly used in traditional fever remedies in parts of Malaysia and southern Thailand (Hanafi et al., 2018).

Despite its benefits, the consumption of kabau requires specific preparation due to the presence of sulfur-containing compounds like jengkolic acid, which can cause a strong odor and digestive disturbances. Traditional processing methods such as soaking, sprouting, or boiling are commonly practiced to reduce these effects (Fattorusso et al., 2012; Komariah & Hartana, 2016).

d. Pharmacology

Nowadays, fruit as fresh vegetables or dietary supplements, and its wood as construction materials and domestic appliances, although kabau plants are utilized as traditional remedies in numerous parts of Indonesia and Malaysia, including antibacterial (Fanisah et al., 2023; Irawan et al., 2018; Mlozi et al., 2022; Teh et al., 2022), antifungal, antioxidant (Liyana et al., 2019; Teh et al., 2022), anti-diabetes (Hanafi et al., 2018; Ifaya et al., 2021; Wahidah et al., 2018), anti-uric acid (Styani et al., 2018), stomach pain treatment, and fever (Silalahi, 2015). A growing body of pharmacological evidence supports the traditional use of kabau as a medicinal food and herbal remedy, particularly in relation to antioxidant, antidiabetic, anti-hyperuricemic, and antimicrobial activities. These bioactivities are largely consistent with its phytochemical profile dominated by phenolics, flavonoids, terpenoids, and sulfur-containing amino acids (Hanafi et al., 2018; Irawan et al., 2018; Riasari et al., 2019; Rahmawati et al., 2020).

Antioxidant and cytoprotective activity. Multiple studies have demonstrated strong in vitro antioxidant activity of kabau extracts. Husks, seed shells, and seed flesh show significant free radical scavenging (DPPH), ferric reducing antioxidant power (FRAP), and oxygen radical absorbance capacity (ORAC) values, with the 99.9% ethanol seed husk extract often exhibiting the highest activity (Irawan et al., 2018; Riasari et al., 2019; Rahmawati et al., 2020; Teh et al., 2022). In general, extracts with higher total phenolic content show lower IC₅₀ values in DPPH assays, indicating a direct correlation between phenolic concentration and antioxidant potency. Such antioxidant capacity is relevant to the traditional use of kabau to maintain stamina and as a general “health tonic”, and provides a mechanistic rationale for its potential in mitigating oxidative-stress-related disorders such as diabetes and cardiovascular disease (West, 2000; Sayuti & Yenrina, 2015).

Antidiabetic and metabolic effects. The antidiabetic potential of *A. bubalinum* has been investigated through both enzyme inhibition assays and in vivo animal models. Methanol extracts of kabau seed shells have shown promising inhibitory effects against carbohydrate-digesting enzymes (α -glucosidase and α -amylase), suggesting that post-prandial hyperglycemia could be attenuated via delayed carbohydrate digestion and glucose absorption (Hanafi et al., 2018). In an alloxan-induced

diabetic mouse model, ethanolic seed extract (70% ethanol) administered orally at doses of 95–380 mg/kg body weight significantly reduced blood glucose levels compared with negative controls; the lowest dose (95 mg/kg) produced glucose reductions comparable to the standard drug metformin (Wahidah et al., 2018). These findings align with ethnomedicinal reports from Sumatra and Malaysia, where roasted kabau seeds are consumed as a traditional antidiabetic infusion.

Given the rich flavonoid and phenolic content of kabau, these antidiabetic effects are likely mediated by a combination of enzyme inhibition, antioxidant protection of pancreatic β -cells, and modulation of insulin sensitivity, as has been reported for other polyphenol-rich legumes and functional foods (Arullappan et al., 2022; Ferretti, 2019). However, controlled clinical studies in humans are still lacking, so current evidence should be considered preliminary and supportive rather than definitive.

Table 2. Summary of pharmacological activities reported for *Archidendron bubalinum*

Pharmacological activity	Plant part / extract	Model / assay	Main outcome	References
Antioxidant	Husk, seed shell, seed flesh (EtOH, MeOH)	DPPH, FRAP, ORAC	Low IC ₅₀ ; activity comparable to or approaching positive controls	Irawan et al., 2018; Riasari et al., 2019; Rahmawati et al., 2020; Teh et al., 2022
Antidiabetic (antihyperglycemic)	Seed extract (70% EtOH)	Alloxan-induced diabetic mice	Significant reduction of blood glucose; 95 mg/kg similar to metformin	Wahidah et al., 2018
Enzyme-based antidiabetic	Seed shell methanol extract	α -glucosidase / α -amylase inhibition	Inhibition of carbohydrate-digesting enzymes in vitro	Hanafi et al., 2018
Anti-hyperuricemic (anti-gout)	Seed shell ethyl acetate extract	Xanthine oxidase inhibition, in vitro uric acid	Reduction of uric acid \sim 1/2 of allopurinol; candidate XO inhibitor compounds	Styani et al., 2018
Antibacterial & antifungal	Seeds (kernel)	Inhibition zone, MIC against bacteria & fungi	Antibacterial and antifungal activity with high polyphenol content	Teh et al., 2022
Antioxidant & antimicrobial	Husk, seed shell	DPPH, FRAP, antibacterial tests	Strong antioxidant activity and inhibition of several bacteria	Irawan et al., 2018; Rahmawati et al., 2020
Antifungal (endophytic fungi)	Endophytic fungi from fruit	MIC vs <i>Malassezia</i> furfur	Moderate antifungal activity; MIC 62.5–125 μ g/mL	Agustriani & Widjajanti, 2024

Anti-hyperuricemic (anti-gout) activity. The traditional use of kabau for relieving gout and joint pain has been investigated through xanthine oxidase (XO) inhibition models. Styani et al. (2018) reported that the ethyl acetate extract of kabau seed shells reduced uric acid levels in vitro, with a decrease of about half the effect of

pure allopurinol under similar conditions. LC–MS analysis indicated the presence of terpenoid and flavonoid constituents, as well as candidate peaks structurally related to allopurinol and 2,4,7-trinitrofluorenone, which may contribute to XO inhibition. Polyphenols in general are known to inhibit xanthine oxidase, and the phenolic-rich

profile of kabau offers a plausible explanation for its anti-hyperuricemic potential (Liu et al., 2020).

These results suggest that properly standardized kabau extracts could be further developed as adjuvant therapy for hyperuricemia or gout. Nonetheless, given the potential presence of djenkolic acid and other sulfur compounds, long-term safety studies and careful dose standardization are required before clinical application.

Antibacterial, antifungal, and antimicrobial properties. Antimicrobial studies on kabau have mainly focused on seed and husk extracts. Husks extracted with methanol and ethanol have demonstrated antibacterial activity against Gram-positive and Gram-negative bacteria, which is attributed to the presence of phenolic compounds and fatty acids such as linoleic and palmitic acids (Irawan et al., 2018; Rahmawati et al., 2020). Teh et al. (2022) evaluated the edible seeds and showed that kabau kernels possess notable antibacterial, antifungal, and antioxidant activities, accompanied by substantial polyphenol content. The authors concluded that kabau seeds have potential as a wild edible seed for development into healthy functional foods or nutraceuticals (Teh et al., 2022).

Recent undergraduate research from Sriwijaya University reported that endophytic fungi isolated from kabau fruits (e.g., *Botrytis*, *Fusarium* sp., and *Curvularia*) produce secondary metabolites with antifungal activity against *Malassezia furfur*, a common cause of dandruff. Extracts of these endophytes showed moderate inhibition zones and contained terpenoids, phenols, flavonoids, steroids, and tannins, with minimum inhibitory concentrations in the range of 62.5–125 µg/mL (Agustriani & Widjajanti, 2024). This finding opens an interesting perspective that not only the plant itself but also its associated microbiota can be exploited for antimicrobial agents.

Safety and toxicological considerations. While many studies highlight the beneficial pharmacological properties of kabau, its safety profile must also be considered. Sulfur-containing amino acids, particularly djenkolic acid, are implicated in nephrotoxic events such as “djenkolism” in consumers of related species like *Archidendron jiringa* (jengkol) (case reports of djenkolism; PubChem, 2023; InvivoChem, 2023). Chemotaxonomic and metabolomic databases indicate that djenkolic acid (L-djenkolate) or structurally related metabolites are present in *A. bubalinum* as well, although detailed quantitative

toxicological data for kabau specifically are still limited (NP-MRD, 2022).

Traditional processing techniques such as prolonged boiling with frequent water changes, soaking, or sprouting are widely used by local communities to reduce odor and potential toxicity, and should be emphasized in public health and educational materials. Future pharmacological development of kabau extracts should therefore include rigorous toxicological evaluation, including kidney function markers, crystal formation risk, and potential mutagenicity of specific constituents.

e. Learning Resources Potential

Ethnobotany has become an essential aspect of biology education as it offers contextual insights into the interactions between humans and plants across various cultures. Kabau (*A. bubalinum*), a local plant with significant ethnobotanical value, holds great potential for integration into biology learning. By linking biological concepts with local realities, information about Kabau can enrich learning materials, making lessons more relevant and engaging for students. Moreover, Kabau serves as a bridge between theoretical knowledge and practical applications, helping students understand the connection between biodiversity and everyday life (Fanisah et al., 2023; Suwardi et al., 2023; Rahman et al., 2019).

The integration of Kabau as a learning resource aligns with the biology curriculum, particularly in topics related to biodiversity, ecology, and biotechnology. Through project-based or inquiry-based approaches, students can explore the taxonomy, geographical distribution, and ecological adaptations of Kabau. These learning activities enhance students’ understanding of biodiversity while fostering critical thinking and analytical skills (Nielsen, 1992; Suwardi et al., 2023).

From an ecological perspective, Kabau serves as an excellent example of plant biodiversity in tropical forests. Its unique morphological features, such as the structure of its leaves, flowers, and seeds, provide concrete material for understanding plant adaptations and ecosystem functions. This knowledge supports biology lessons on plant diversity, adaptation, and conservation efforts (Nielsen, 1992).

On the phytochemical front, Kabau contains bioactive compounds such as flavonoids and phenolics, which exhibit significant antimicrobial and antidiabetic properties (Riasari

et al., 2021; Lim, 2015). These attributes allow students to delve into plant secondary metabolism and its pharmacological applications. Simple laboratory experiments, such as extracting bioactive compounds from Kabau seeds, provide a hands-on approach to exploring these concepts.

The traditional uses of Kabau, such as its application in treating fever and abdominal pain,

offer opportunities for discussions on ethnomedicine and sustainable resource management. Students can engage in research projects comparing the antimicrobial efficacy of Kabau extracts with commercial alternatives. This approach bridges traditional knowledge with scientific exploration, enriching the learning experience (Silalahi, 2015; Ramirez, 2007).

Table 3. Framework for Integrating Kabau (*Archidendron bubalinum*) as a Learning Resource in Biology Education

No	Biology Learning Material	Related Topic	Suggested Teaching Strategies	Learning Objectives
1	Biodiversity	Identifying Kabau as a local species	Field observation and classification (Inquiry-Based Learning)	Students can identify Kabau and understand its role in the local ecosystem
2	Ethnobotany	Traditional uses of Kabau in the community	Group discussion and interviews with locals (Problem-Based Learning)	Students understand the relationship between humans and plants through Kabau case study
3	Phytochemistry	Analysis of active compounds in Kabau	Laboratory practical: extraction and phytochemical tests (Experimental Learning)	Students can perform extraction and identify phytochemical compounds in Kabau
4	Plant Ecology	Habitat and distribution of Kabau	Field research and mapping (Project-Based Learning)	Students understand ecological factors affecting Kabau distribution
5	Plant Conservation	Conservation status of Kabau and preservation efforts	Conservation projects and environmental campaigns (Service-Learning)	Students participate in Kabau conservation efforts and raise environmental awareness
6	Biotechnology	Kabau's potential in biotechnology development	Literature review and presentations (Cooperative Learning)	Students explore biotechnology applications of Kabau
7	Nutrition and Health	Nutritional value and health benefits of Kabau	Nutritional analysis and discussion (Discovery Learning)	Students understand Kabau's contribution to health and nutrition
8	Sustainable Agriculture	Kabau cultivation and its role in local agriculture	Visits to local farmers and interviews (Contextual Teaching and Learning (CTL))	Students learn about sustainable agricultural practices through Kabau cultivation
9	Plant Genetics	Genetic variability in Kabau populations	Simple DNA analysis and data interpretation (Guided	Students understand genetic variability concepts

			Inquiry)	using Kabau as a case study
10	Plant Physiology	Kabau's physiological adaptations to the environment	Experiments on environmental factors affecting Kabau growth (Experimental Learning)	Students understand plant adaptation mechanisms through experiments
11	Plant Reproduction Systems	Reproductive patterns and seed dispersal in Kabau	Observation and documentation of reproductive processes (Scientific Inquiry)	Students understand Kabau's life cycle and reproductive strategies
12	Plant Pharmacology	Pharmacological potential of Kabau in traditional medicine	Literature study and pharmacology simulation (Case-Based Learning)	Students learn about plant pharmacological applications through Kabau case study
13	Economic Botany	Economic value of Kabau for local communities	Market analysis and interviews with stakeholders (Socio-Scientific Issues-Based Learning)	Students understand Kabau's economic contributions to local communities
14	Environmental Education	Kabau's role in ecosystems and environmental education	Development of educational modules and outreach activities (Project Based Learning)	Students develop environmental education materials based on Kabau
15	Food Technology	Processing Kabau into innovative food products	Practical food processing and product evaluation (STEM Education)	Students learn how to process Kabau into food products and understand its processes

Kabau also supports the integration of STEM (Science, Technology, Engineering, and Mathematics) concepts into biology education. Students can design innovative Kabau-based products, such as herbal supplements or educational materials, that combine biological principles with technological and engineering solutions. Such activities foster interdisciplinary learning and demonstrate the real-world applications of biological knowledge (Permanasari, 2016; Dare et al., 2018).

Incorporating Kabau as a learning resource encourages students to explore the practical benefits of local plants in health and economic contexts. This approach emphasizes the connections between basic science and technological innovation, fostering a deeper appreciation for biodiversity and its applications. By engaging with Kabau, students not only gain a broader understanding of scientific principles but

also develop critical thinking, creativity, and an awareness of sustainability.

The study of Kabau plants can also enhance students' environmental awareness. As a representative species of tropical rainforests, Kabau provides a platform for discussions on habitat conservation and biodiversity. Through environment-based activities, such as identifying threats to Kabau populations and exploring conservation strategies, students learn the significance of preserving local plants for ecosystem sustainability (Milaturrahmah et al., 2017; Ramirez, 2007). This aligns with broader educational goals, fostering responsibility and environmental stewardship among learners.

Furthermore, using Kabau in biology education integrates local cultural knowledge with scientific literacy, creating meaningful and contextualized learning experiences. By leveraging the potential of this plant, educators can support sustainable development and

promote educational goals that align with 21st-century competencies. This approach not only enriches the biology curriculum but also instills a sense of connection to local biodiversity and its broader applications.

CONCLUSION

There is rich traditional knowledge regarding the use of kabau (*Archidendron bubalinum* (Jack) I.C. Nielsen) as both a food source and a medicinal plant in various regions of Sumatra and neighbouring areas. Ethnobotanical evidence shows that local communities have long utilized kabau for daily consumption, for treating metabolic and digestive complaints, and as part of cultural practices, while also maintaining specific processing techniques to reduce its pungent odour and potential toxicity. This knowledge positions kabau as an important element of local biocultural heritage that deserves to be documented, preserved, and revitalized.

From a scientific perspective, the literature indicates that kabau contains diverse secondary metabolites, including phenolics, flavonoids, terpenoids, fatty acids, and sulfur-containing amino acids associated with djenkolic acid. These compounds are consistent with the strong in vitro antioxidant activity of kabau extracts and support preliminary pharmacological findings related to antidiabetic, anti-hyperuricemic, antibacterial, and antifungal effects. At the same time, the presence of sulfur-based constituents highlights the need for careful attention to safety issues, particularly nephrotoxicity, and for standardized processing and dosage guidelines before wider therapeutic application.

In the context of education, kabau offers considerable potential as a local, contextual learning resource in biology and science education. Its botanical, ecological, ethnobotanical, phytochemical, and pharmacological dimensions can be used to develop integrated learning activities that link scientific concepts with students' local environment and cultural experiences. Such integration can foster scientific literacy, critical thinking, and sustainability awareness while strengthening students' appreciation of local biodiversity. Future research should therefore focus on (1) more detailed phytochemical and toxicological studies, (2) experimental and clinical investigations to validate pharmacological claims, and (3) design-based and classroom-based studies that develop, implement, and evaluate kabau-

based learning resources in different educational settings.

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