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A Review on Phytochemicals and Pharmacological Activities as Ethnomedicinal Uses of Duku (*Lansium domesticum* Corr.)

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Abstract

BACKGROUND: *Lansium domesticum* Corr. is a plant that is easily found in Indonesia. People use the fruit to be sold because it has a good taste. Some people use other parts of the plant as medicine. This plant has great potential to be developed as a standardized traditional medicine.

AIM: This article review aims to collect information on secondary metabolite compounds from *L. domesticum* Corr. and its pharmacological activities as antioxidants, antibacterials, and cytotoxics.

METHODS: Data on *L. domesticum* Corr. or duku were sought and collected for this miniature estimate and perspective. We use the major search engines with specific keywords such as *L. domesticum* Corr.; duku; morphology; pharmacological effects; secondary metabolites; *in vitro;* and *in vivo*.

RESULTS: This review shows that *L. domesticum* Corr. have antioxidant, antibacterial, and cytotoxic activity of various compounds based on the test method used.

CONCLUSIONS: Some parts of *L. domesticum* Corr. such as leaves, fruit, fruit skins, and seeds contain secondary metabolite compounds. The most common type of active compound is the steroid/terpenoid group. These compounds are responsible for their pharmacological activities such as antioxidants, antibacterials, and cytotoxics.

Introduction

The Indonesian country is made up of ethnic groups from all over the world. A country with a wide range of medications traditional Indonesian ingredients, including medicinal herbs, is used to make this traditional dish [1], [2]. There are around 30,000 kinds of plants in Indonesia, with 7000 of them having medicinal characteristics. Indonesia's biodiversity is thought to be second only to Brazil's [3]. This makes Indonesia a country with great potential to develop traditional medicines and natural products in medicine. Herbal medicine has been widely recognized in both the developing and developed countries across the world [4]. The use of medicinal plants in medicine is growing due to a variety of materials for medicinal plants, a greater risk-to-use ratio profit, and the weakness of synthetic chemical medications [5].

Lansium domesticum known as duku in Indonesia is a fruit-producing plant that can be found in tropical countries, especially in Indonesia [6]. Duku has a number of societal advantages. In addition to the fruit's great nutritional content, the community believes that duku offers medicinal properties for ailments such as malaria, dysentery, and diarrhea [7]. Duku has been empirically believed that society has many benefits. This plant's advantages may be felt in a variety of disciplines, including agriculture, chemistry, and health. The effectiveness of duku has been reported in several investigations due to the presence of secondary metabolites [8]. However, it is vital to be aware of the scientific facts pertaining to the activity and biological potential of duku. As a consequence, this is the first study to look at the pharmacological action of duku based on the research findings.

Method

Data on *L. domesticum* Corr. or duku were sought and collected for this miniature estimate and

perspective. We use the major search engines, namely, Google Scholar, PubMed, Science Direct, and SciFinder. The search keywords used were from *L. domesticum* Corr.; duku; morphology; pharmacological effects; secondary metabolites; *in vitro;* and *in vivo*. The authors rate, discuss, and discuss selected articles. This perspective reflects the author's opinion about the pharmacological activity of *L. domesticum* Corr.

Morphological characteristics

This plant, also known as duku (*L. domesticum* Corr.), is a Southeast Asian native and one of Indonesia's seasonal favorite fruits. The plant is a tropical fruit that is both commercially useful and nutritious. It grows natively in Sumatra, Kalimantan, Sulawesi, and Java in Indonesia [9]. Duku is grown and farmed in various areas of those regions. Because it grows in several countries, duku has many synonyms (Table 1).

Table 1: Synonym for duku in various regions [10]

Region	Synonym
Indonesian	Duku, luku, kokosan, and langsat
Burmese	Duku and langsak
English	Langsat and duku
Philippines	Lanzone, lanzon, lansones, and lanson
Malaysia	Langseh and langsep
Thailand	Duku, longkong, and langsat
Vietnamese	Bonbon

Duku is a Meliaceae plant that grows as a tall tree that is erect and persistent. The tree may grow up to 20 m tall, with a trunk diameter of 35–40 cm. The trunk has deep grooves and sticks out above the ground. The bark is broken, white sticky, and brown-greenish or gray. The skin on the stem is thin and tough to remove [11]. Duku leaves are unusual compound leaves that are placed in a zigzag pattern. Each leaflet is composed of 5–7 long elliptical, flat-edged, asymmetrical base, and tapering ends leaflets. Duku leaves are dark green or slightly yellowish on both sides. Compound interest is a type of interest that comes in bunches. The flowers have a bowl-like shape and are known as sissy flowers (there are pistils and stamens in one flower). The flower petals are five strands thick and thick. The floral crown is thick and made up of 4–5 strands. There will be 4–5 chambers in the fruit [12].

The fruit comes in bunches, with a round or circular shape that is around 2–4 cm in diameter. The juvenile duku fruit has a green skin that becomes yellow as it ripens. Flesh is thick, white, clear, and somewhat translucent, with a chewy texture and a sweet or sweet acidity flavor [13]. When ripe duku fruit is opened, it does not emit sap, the seeds are small and few, the flesh is thick and copious, and the flesh has a pleasant taste [14]. Duku plants require around 2000–3000 mm of annual rainfall, a temperature of 25–25°C, and a 3–4 week dry season to boost bloom growth. Duku grows at a height of < 600 m, with a clay soil type, a pH of 5.5–6.6, and adequate drainage [15], [16].

Natural product identification of L. domesticum Corr.

Natural products are secondary metabolites that come from plants or animals. Natural products are pharmacological and biologically active chemical compounds found in nature [17]. Natural products are commonly employed in medication development and discovery. Many of the plant's secondary metabolites have noteworthy pharmacological properties [18]. Not many secondary metabolites have been identified from this plant (Table 2). Hence, it requires a more intimate touch to obtain data about these compounds. This is necessary for drug development.

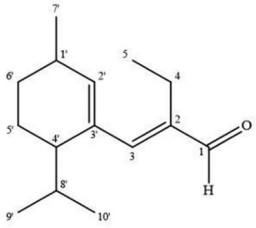
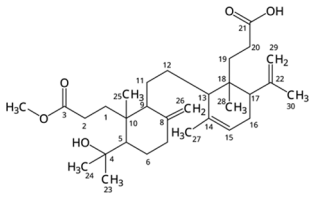
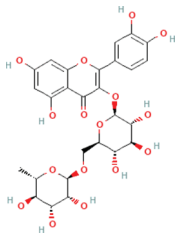
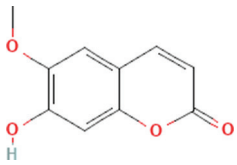
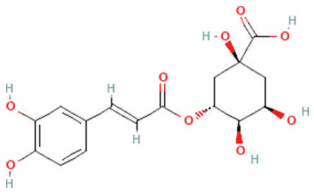
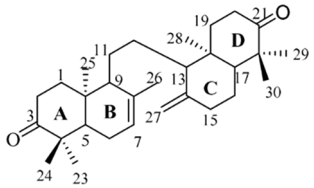
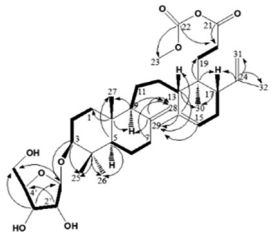
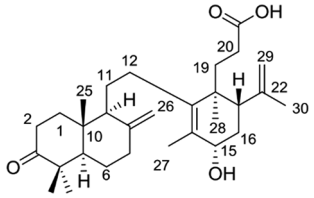
Secondary metabolites are non-nutritive compounds that play a crucial function in an organism's survival in the environment [19]. Plants are known to contain a wider range of secondary metabolites than animals and microbes. The majority of secondary metabolites can be employed as a pharmaceutical component [20]. Tannins, flavonoids, alkaloids, steroids/terpenoids, phenols, and other chemical substances found in plants can be employed as therapeutic medicines [21], [22], [23]. The components of these bioactive chemicals are largely produced from secondary metabolites and are pharmacological [24].

In *L. domesticum* Corr., many researchers have attempted to identify active metabolite compounds. It was reported that these plant materials such as leaves, fruit, fruit peel, and seeds are rich in active metabolite compounds (Table 2). Some of them are new compounds and this will be very useful for drug development [25]. Secondary metabolites, when taken as a single component or in combination, can be effective and safe even when synthetic medications fail [26]. They may potentially enhance or synergize the effects of other pharmaceutical ingredients [27] for further discussion will be discussed the relationship of secondary metabolites and their pharmacological activity in *L. domesticum* Corr.

Pharmacological activity of L. domesticum Corr.

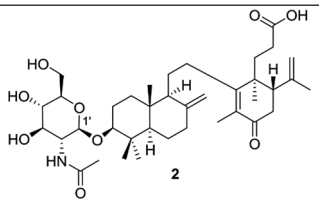
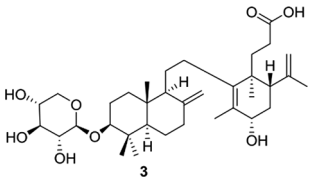
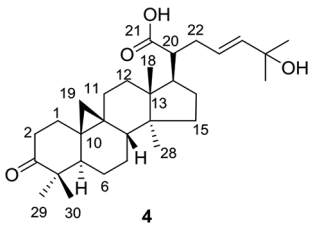
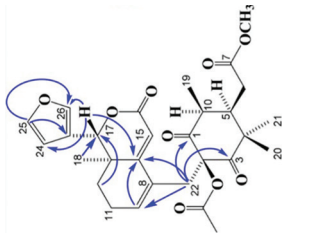
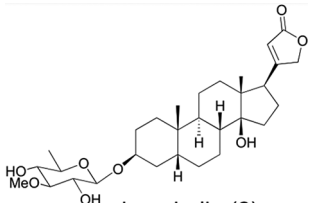
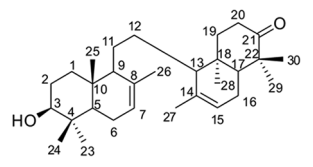
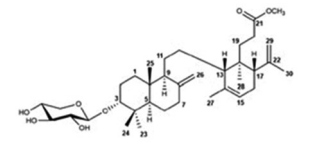
Duku (*L. domesticum* Corr.) is an unusual and potentially valuable tropical fruit from the Meliaceae (Mahogany) family, however, it is not yet widely planted [39]. The majority of the fruits sold in marketplaces come from trees in community plantations. This plant has been grown for a long time, and it was first noted by Ma Huan, a Chinese traveler, in the year 1413 [40]. This tropical plant is essential not only as a delicious fruit that is commonly consumed fresh for dessert but it may also be used in cosmetics since its extract contains antioxidant and moisturizing properties, as well as little to no side effects and a strong safety profile [41]. Because its fruit, seed, and bark contain unique chemical constituents, humans utilized this plant

Table 2: Chemical contents isolated from *Lansium domesticum* Corr.

Source	Phytochemical group/name	IUPAC names	Chemical structure	References
Fruit peels	Sesquiterpene aldehyde	2-ethyl, l, 3-(2'-menthene) propanol		[28]
Fruit peels	Triterpenoid/lamesticumin A	3-[(1*S*,2*S*,6*S*)-2-[2-[(1*S*,2*R*,3*R*)-3-(2-hydroxypropan-2-yl)-2-(3-methoxy-3-oxopropyl)-2-methyl-6-methylidenecyclohexyl] ethyl]-1,3-dimethyl-6-prop-1-en-2-ylcyclohex-3-en-1-yl] propanoic acid		[29]
Fruit	Flavonoid/rutin	2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2*S*,3*R*,4*S*,5*S*,6*R*)-3,4,5-trihydroxy-6-[(2*R*,3*R*,4*R*,5*R*,6*S*)-3,4,5-trihydroxy-6-methyloxan-2-yl] oxymethyl] oxan-2-yl] oxychromen-4-one		[30]
Fruit	Coumarin/scopoletin	7-hydroxy-6-methoxychromen-2-one		
Fruit	Polyphenol/chlorogenic acid	(1*S*,3*R*,4*R*,5*R*)-3-[(*E*)-3-(3,4-dihydroxyphenyl) prop-2-enoyl] oxy-1,4,5-trihydroxycyclohexane-1-carboxylic acid		
Fruit peels	Onoceradienedione 1	8,14-Secogammacera-7,14 (27)-dien-3,21-dione (onoceradienedione)		[31]
Fruit peels	Triterpene glycoside/ lansioside D	3-[(1*S*,2*S*,6*S*)-2-[2-[(1*S*,4*aR*,6*S*,8*aR*)-6-[(2*R*,3*R*,4*R*,5*S*,6*R*)-3-acetamido-4,5-dihydroxy-6-(hydroxymethyl) oxan-2-yl] oxy-5,5,8*a*-trimethyl-2-methylidene-3,4,4*a*,6,7,8-hexahydro-1*H*-naphthalen-1-yl] ethyl]-1,3-dimethyl-6-prop-1-en-2-ylcyclohex-3-en-1-yl] propanoic acid		[32]
Leaves	Onoceranoid triterpenoid/ Lansium acid X	-		[33]

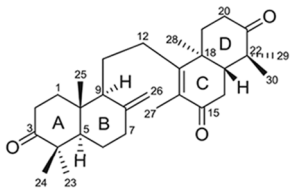
(Contd...)

Table 2: ***(Continued)***

Source	Phytochemical group/name	IUPAC names	Chemical structure	References
Leaves	Onoceranoid triterpenoid/ Lansium acid XI	-		[33]
Leaves	Onoceranoid triterpenoid/ Lansium acid XII	-		[33]
Leaves	Onoceranoid triterpenoid/ Lansium acid XIII	-		[33]
Seed	Tetranortriterpenoids/ Langsatides A	-		[34]
Seed	Tetranortriterpenoids/ Langsatides A	-		[34]
Leaves	Cardiac glycoside/Honghelin	-		[35]
Seed	Onoceranoid triterpenes	3-hydroxy-8,14-secogammacera-7,14-dien-21-one		[36]
Fruit	Onoceranoid triterpenes/ methyl lansioside C	-		[37]

(Contd...)

Table 2: ***(Continued)***

Source	Phytochemical group/name	IUPAC names	Chemical structure	References
Fruit peels	Onoceranoid triterpenes/ Lamesticumin G	-		[38]

to cure digestive disorders and malaria [42]. Now, the activities of this plant have been more explored. Some of the activity reports will be explained in this article.

Antioxidant activity

Antioxidants are required by the body because they limit the beginning and progression of substrate oxidation. Beta-hydroxy acid, tert-butyl hydroquinone, propyl gallate, and butylated hydroxytoluene are examples of synthetic antioxidants that have been widely employed across the world [43], [44]. However, these synthetic antioxidants have negative side effects on the heart and lungs, including carcinogenic and cytotoxic consequences [45]. Natural items having antioxidant capabilities, such as *L. domesticum*, have been discovered (Table 3).

Using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) technique, the antiradical potential of *L. domesticum* seeds extract and fractions was evaluated. In comparison to the n-hexane fraction, water fraction, and methanol extract, the ethyl acetate fraction provided a significant contribution as an antioxidant, with IC_{50} values of 8.938 ± 0.031, 11.012 ± 0.094, 13.898 ± 0.81, and 14.624 ± 0.456 μg/mL, respectively [42]. The negative consequences of NO overexpression in the host organism have traditionally been linked to a variety of illnesses, including human vascular and cardiac ailments. Two undescribed compounds from *L. domesticum* leaves extract, 17(20)E-dyscusin B and 17(20)Z-dyscusin B, demonstrated strong NO inhibition with IC_{50} values of 9.13 and 14.03 μM, respectively [46].

L. domesticum Corr. leaves were extracted using three distinct solvents: Water, chloroform, and methanol, in both hot and cold procedures. Antioxidant activity (DPPH radical scavenging and lipid peroxidation inhibition) was assessed in the crude extracts. The hot process methanol crude extract had the best DPPH radical scavenging activity (SC_{50} values of 8.72 ± 0.54 mg/ml) while the water crude extract obtained by the hot process gave the best activity as lipid peroxidation inhibitor (IPC50 values of 3.29 ± 0.30 mg/ml) [47].

L. domesticum shows good potential as an antioxidant based on the report. *In vitro* chemical or cell culture tests are routinely employed to determine antioxidant activity. Animal bioassays are also becoming increasingly popular as a way to more precisely identify the effects of these chemicals on organ function and development, as well as in clinical trials. However, scientists are working to develop new, simpler, and

Table 3: Antioxidant activity of *Lansium domesticum* Corr.

No.	Sample	Method	Result	References
1	*Lansium domesticum* seeds extract and fractions • Methanol extract • Water fraction • Ethyl acetate fraction • n-Hexane fraction	DPPH assay	IC_{50} (μg/mL) values: • 14.6 ± 0.4 • 13.8 ± 0.8 • 8.9 ± 0.03 • 11.0 ± 0.09	[42]
2	Two undescribed compounds from *Lansium domesticum* leaves extract • 17 (20) E-dyscusin B • 17 (20) Z-dyscusin B	Nitric oxide inhibition	IC_{50} (μM) values: • 9.13 • 14.03	[46]
3	The fraction of *Lansium domesticum* peel fruit extract ethanol (mg/mL) • Dichloromethane fraction (2.0) • Ethyl acetate fraction (2.0) • Water fraction (2.0)	Hydroxyl radical scavenging activity	% inhibition degradation: • 43.94 ± 1.03 • 42.70 ± 0.86 • 93.44 ± 0.84	[30]
4	*Lansium domesticum* leaves extract • Water extract • Methanol extract • Chloroform extract	DPPH radical scavenging assay and lipid Peroxidation inhibition	Scavenging concentration at 50% activity (mg/mL): • 5.40 ± 1.23 • 8.72 ± 0.54 • 6.15 ± 0.78 Inhibition peroxidation concentration at 50% activity (mg/mL) • 3.29 ± 0.30 • 4.61 ± 0.65 • 18.77 ± 1.78	[47]

perhaps faster approaches that might supplement or replace established assays, notably for quality assurance screening of traditional medicine products. Various types of methods have been used to identify the antioxidant activity of *L. domesticum* Corr.

Antibacterial activity

Antibiotics were discovered, developed, and used clinically in the 19th century, greatly reducing the public health risks associated with bacterial infections. The growth of bacterial resistance to current chemotherapeutic drugs as a result of their injudicious usage, on the other hand, is concerning. To overcome this problem, antibacterial research from medicinal plants was developed. Many medicinal plants have been used as traditional remedies to cure illnesses of pathogenic origin in humans all across the world. Plant extracts contain a variety of bioactive chemicals such as polyphenols, terpenes, and phytosterols, which operate in a variety of ways to inhibit or kill bacteria. This article will explain the activity of *L. domesticum* Corr. as an antibacterial based on research results.

The aqueous seeds extract of *L. domesticum* Corr. was showed antibacterial activity. As test organisms, *Escherichia coli* and *Staphylococcus aureus*, two harmful bacteria, were employed [48]. Antibacterial activity of an ointment containing *L. domesticum* seed extract was also reported. Ointment with a concentration of 10% *L. domesticum* seed extract showed inhibition against *S. aureus* [49]. On *S. aureus* and *Klebsiella pneumoniae* bacteria, inhibition of the n-hexane extract of *L. domesticum* fruit seeds exhibited the highest clear zone diameter value supplied by the lowest concentration of 10% using the disc and well technique [50].

These findings indicate that the extract has either strong antibacterial efficacy or a high concentration of an active component. The findings show that *L. domesticum* can be used in traditional medicine to treat diseased skin. As a result, when the widths of the inhibition zones and the MIC are taken into account, the wound healing activity of this plant appears to be the most intriguing for further research. In addition, the action of this plant as an antibacterial is an interesting thing to research and report on.

Cytotoxic activity

Uncontrolled cell proliferation and differentiation are hallmarks of cancer. It has the ability to infect organs and tissues, and it is a serious public health concern in both developed and developing countries [45]. The assessment of cytotoxic activity against cancer cell lines *in vitro* and animal cancer models *in vivo* was a major factor in the development of new anticancer drugs from natural sources such as plants, marine creatures, and microorganisms [51]. Plants have been used to cure cancer for 1000 of years. Vinblastine and vincristine, obtained from the *Madagascar periwinkle*, *Catharanthus roseus* G. Don. (Apocynaceae), and paclitaxel, isolated from the bark of *Taxus brevifolia* Nutt. (Taxaceae), are among the more than 3000 plant species that have been reported for cancer therapy [52], [53]. This study reports on the potential of *L. domesticum* Corr. as an anticancer based on research that has been found (Table 4).

Cytotoxic activity shows the potential of a material as an anticancer agent. Based on the data in Table 4, *L. domesticum* Corr. has cytotoxic activity on several types of cancer cells such as liver cancer cells (HepG2), colon cancer cells (WidR and HT-29), breast cancer cells (T47D), oral cancer cells (KB), and melanoma cancer cells (B16F10). Cytotoxic activity was obtained from various types of plant parts such as seeds, fruits, fruit peels, and leaves. Not only that, secondary metabolites that have been isolated have also shown cytotoxic activity on cancer cells, namely, sesquiterpene aldehydes.

L. domesticum Corr. is reported to contain a lot of secondary metabolites of the steroid/terpenoid group. Terpenoids are chemical molecules that are made up of five carbon units (isoprene) that have been built and changed in various ways [59]. Terpenoids are a group of essential secondary metabolites in plants that have a variety of forms. They are the most numerous molecules in natural goods including in this plant. With their specific structural properties and strong anticancer activity, terpenoids have piqued the interest of many

Table 4: Cytotoxic activity of *Lansium domesticum* Corr.

Sample	Method	Results	References
Chloroform extract of young fruit	*In vitro* in KB, HT-29, HepG2, and B16F10 cell lines	IC_{50} (μg/mL) value was determined by SRB assay 983.81 ± 13.17 (KB cell), 934.89 ± 52.43 (HT-28 cell), 934.00 ± 46.20 (HepG2 cell), and 421.5 ± 12.98 (B16F10 cell)	[54]
Ethyl acetate extract of peel fruit	*In vitro* in T47D cells line	The IC_{50} is 29.41 ± 0.67 μg/mL	[29]
Chloroform young fruit extract	*In vitro* in KB cells line	The IC_{50} values is 603.45 ± 55.35 μg/mL	[55]
Kokosanolid A and C from *Lansium domesticum* Corr. seed	*In silico* test of molecular interactions of kokosanolid A and kokosanolid C with the estrogen receptor α (ERα)	Kokosanolid A and C showed strong bond-free energy (−8.8 kcal/mol and−8.7 kcal/mol) to ERα. These two compounds have molecular mechanism to inhibit ERα in breast cancer cells.	[56]
Methanol extract of *Lansium domesticum* Corr. fruit	*In vitro* in HT-29 cells line	IC_{50} value was determined by MTT assay after 2 days incubated (50.00 ± 0.02 μg/mL)	[57]
Active compound of fruit peel extract (sesquiterpene aldehyde)	*In vitro* in T47D and HepG2 cell lines	IC_{50} (μg/mL) value was determined by MTT assay 48.58 ± 0.96 (T47D) and 127.45 ± 25.76 (HepG2)	[28]
Active compound of fruit peel extract (sesquiterpene aldehyde)	*In vitro* in WidR cells line	The IC_{50} is > 50 μg/mL	[58]

medicinal chemists, and they have the potential to be lead molecules in the development of effective and safe antitumor medicines [60], [61], [62].

Conclusions

L. domesticum Corr. is a fruit-producing plant known as duku and is found in Southeast Asia, one of which is Indonesia. This plant has been widely used by the community such as its fruit that can be consumed so that it is sold in the market to improve the economy. Some parts such as leaves, fruit, fruit skins, and seeds contain secondary metabolite compounds so they are used as folk remedies. Based on the data that have been collected, *L. domesticum* Corr. has good antioxidant activity properties, is efficacious as an antibacterial, and has the potential to be developed as an anticancer because it has cytotoxic properties. Further studies are needed to explore the activity of *L. domesticum* Corr. so that it can be developed as a standardized herbal.

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References

1. Taek MM, Ew BP, Agil M. Plants used in traditional medicine for treatment of malaria by Tetun ethnic people in West Timor Indonesia. Asian Pac J Trop Med. 2018;11(1):630-7. https://doi.org/10.4103/1995-7645.246339
2. Supiandi MI, Ege B, Julung H, Zubaidah S, Mahanal S. Ethnobotany of traditional medicine in Dayak Jangkang tribe, Sanggau district, West Kalimantan, Indonesia. Biodiversitas. 2021;22(12):5417-24. https://doi.org/10.13057/biodiv/d221224
3. Susanti R, Zuhud EA. Traditional ecological knowledge and biodiversity conservation: The medicinal plants of the Dayak Krayan people in Kayan Mentarang National Park, Indonesia. Biodiversitas. 2019;20(9):2764-79. https://doi.org/10.13057/biodiv/d200943
4. Verma R, Gangrade T, Punasiya R, Ghulaxe C. Rubus fruticosus (blackberry) use as an herbal medicine. Pharmacogn Rev. 2014;8(16):101-4. https://doi.org/10.4103/0973-7847.134239 PMid:25125882
5. Rosidah Y, Widjaja SS, Auliafendri N, Lubis MF, Muhammad M, Satria D. Phytochemicals analysis and immunomodulatory activity of saurauia vulcani korth. leaves extracts towards raw 264.7 cell. Rasayan J Chem. 2021;14(2):1378-83. https://doi.org/10.31788/rjc.2021.1426075
6. Yulita KS. Genetic variations of *Lansium domesticum* Corr. accessions from Java, Sumatra and Ceram based on Random Amplified Polymorphic DNA fingerprints. Biodivers J Biol Divers. 2011;12(3):125-30. https://doi.org/10.13057/biodiv/d120301
7. Darmadi D, Meilasri S. Secondary metabolite compounds of duku skin (*Lansium domesticum* corr) as an inhibitor of egg maturation of egg *Ascaris lumbriccoides*. Klin Sains J Anal Kesehat. 2019;7(2):68-75. https://doi.org/10.36341/klinikal_sains.v7i2.1056
8. Subandrate S, Sinulingga S, Wahyuni S, Altiyan MF, Fatmawati F. Antioxidant potential of *Lansium domesticum* corr. seed extract in white male rat (*Rattus novergicus*) induced by alcohol. Molekul. 2016;11(1):1-8.
9. Shankar S, Jaiswal L, Aparna RS, Prasad RG. Synthesis, characterization, *in vitro* biocompatibility, and antimicrobial activity of gold, silver and gold silver alloy nanoparticles prepared from *Lansium domesticum* fruit peel extract. Mater Lett. 2014;137:75-8. https://doi.org/10.1016/j.matlet.2014.08.122
10. Nyoman I, Sjaifullah A, Cahyani DJ, Ayu WD. Onoceranoid triterpene from langsep leaf (*Lansium domesticum* Corr.) and its insecticide activity to *Spodoptera littura*. J ILMU DASAR. 2017;18(1):9-16.
11. Ni'mah T, Oktarina R, Mahdalena V, Asyati D. Potential of duku seed extract (*Lansium domesticum* Corr) against *Aedes aegypti*. Bul Penelit Kesehat. 2015;43(2):131-6. https://doi.org/10.22435/bpk.v43i2.4147.131-136
12. Hanum L, Negara ZP, Dahlan Z. Morphological diversity of *Lansium domesticum* Corr in South Sumatra. Sci Technol Indones. 2018;3(1):41-4. https://doi.org/10.26554/sti.2018.3.1.41-44
13. Wong KC, Wong SW, Siew SS, Tie DY. Volatile constituents of the fruits of *Lansium domesticum* correa (Duku and Langsat) and *Baccaurea motleyana* (Muell. Arg.) Muell. Arg. (Rambai). Flavour Fragr J. 1994;9(6):319-24. https://doi.org/10.1002/ffj.2730090608
14. Pontoh J, Kamu VS, Sitorus LP. Analysis of organic acid in langsat (*Lansium domesticum* var *pubescens*) and Duku (*Lansium domesticum* var. *domesticum*) fruits by reversed phase HPLC technique. Int J ChemTech Res. 2015;8(7):238-42.
15. Techavuthiporn C, Langsat *Lansium domesticum*. Amsterdam, Netherlands: Elsevier Inc.; 2018.
16. Huang WY, Cai YZ, Corke H, Sun M. Survey of antioxidant capacity and nutritional quality of selected edible and medicinal fruit plants in Hong Kong. J Food Compos Anal. 2010;23(6):510-7. https://doi.org/10.1016/j.jfca.2009.12.006
17. Hasibuan PA, Harahap U, Sitorus P, Lubis MF, Satria D. *In-silico* analysis of vernonioside d and vernonioside e from vernonia amygdalina delile. Leaves as inhibitor of epidermal growth factor receptor (egfr) and mammalian target of rapamycin (mtor). Rasayan J Chem. 2021;14(3):1539-43. https://doi.org/10.31788/RJC.2021.1436092
18. Hasibuan PA, Munir D, Pertiwi D, Satria D, Lubis MF. Flavonoids constituent analysis and cell cycle inhibition activity of ethylacetate extract of *Vernonia amygdalina* delile. Leaves on lung cancer cell line. Rasayan J Chem. 2020;13(4):2577-81. https://doi.org/10.31788/RJC.2020.1345625
19. Venugopala KN, Rashmi V, Odhav B. Review on natural coumarin lead compounds for their pharmacological activity. Biomed Res Int. 2013:2013:963248. https://doi.org/10.1155/2013/963248
20. Batiha GE, Beshbishy AM, Ikram M, Mulla ZS, Abd El-Hack ME, Taha AE, *et al.* The pharmacological activity, biochemical properties, and pharmacokinetics of the major natural polyphenolic flavonoid: Quercetin. Foods. 2020;9(3):374. https://doi.org/10.3390/foods9030374 PMid:32210182
21. Rios JL, Simeon S, Villar A. Pharmacological activity of aporphinoid alkaloids. A review. Fitoterapia. 1989;60(5):387-412. https://doi.org/10.63019/ajb.v1i2.467

22. Sallam IE, Abdelwareth A, Attia H, Aziz RK, Homsi MN, von Bergen M, *et al.* Effect of gut microbiota biotransformation on dietary tannins and human health implications. Microorganisms. 2021;9(5):965. https://doi.org/10.3390/microorganisms9050965
PMid:33947064
23. Biswas D, Nazir R, Biswas P, Kumar V, Nandy S, Mukherjee A, *et al.* Endophytic sources of diosgenin, a natural steroid with multiple therapeutic values. S Afr J Bot. 2020;134:119-25. https://doi.org/10.1016/j.sajb.2020.04.009
24. Qurrohman T, Basyuni M, Hasibuan PA. Polyisoprenoids from avicennia marina induces on p13k, akt1, mammalian target of rapamycin, egfr, and p53 gene expression using reverse transcription-polymerase chain reaction. Open Access Maced J Med Sci. 2020;8(A):146-52. https://doi.org/10.3889/oamjms.2020.3328
25. Celik S, Ozkok F, Ozel AE, Sahin YM, Akyuz S, Sigirci BD, *et al.* Synthesis, FT-IR and NMR characterization, antimicrobial activity, cytotoxicity and DNA docking analysis of a new anthraquinone derivate compound. J Biomol Struct Dyn. 2020;38(3):756-70. https://doi.org/10.1080/07391102.2019.1587513
PMid:30890106
26. Hasibuan PA, Harahap U, Sitorus P, Satria D. The anticancer activities of *Vernonia amygdalina* Delile. Leaves on 4T1 breast cancer cells through phosphoinositide 3-kinase (PI3K) pathway. Heliyon. 2020;6(7):e04449. https://doi.org/10.1016/j.heliyon.2020.e04449
27. Sukatendel K, Siregar MF, Natadisastra M, Nasution IP, Ilyas S, Tala MR, *et al.* Benefits of *Nigella sativa* extract protecting ovary due to cisplatin chemotherapy. Open Access Maced J Med Sci. 2021;9(A):680-7. https://doi.org/10.3889/oamjms.2021.6446
28. Fadhilah K, Wahyuono S, Astuti P. Fractions and isolated compounds from *Lansium domesticum* fruit peel exhibited cytotoxic activity against t-47d and hepg2 cell lines. Biodiversitas. 2021;22(9):3743-8. https://doi.org/10.13057/biodiv/d220918
29. Wahyuono S, Fadhilah K, Astuti P. A bioactive compound isolated from Duku (*Lansium domesticum* Corr) fruit peels exhibits cytotoxicity against T47D cell line. F1000Research. 2021;9:3. https://doi.org/10.12688/f1000research.21072.2
PMid:34136135
30. Klungsupya P, Suthepakul N, Muangman T, Rerk-Am U, Thongdon-A J. Determination of free radical scavenging, antioxidative DNA damage activities and phytochemical components of active fractions from *Lansium domesticum* corr. Fruit. Nutrients. 2015;7(8):6852-73. https://doi.org/10.3390/nu7085312.
PMid:26287238
31. Labibah Q, Tun KN, Aminah NS, Kristanti AN, Ramadhan R, Takaya Y, *et al.* Cytotoxic constituent in the fruit peel of *Lansium domesticum*. Rasayan J Chem. 2021;14(2):1336-40. https://doi.org/10.31788/RJC.2021.1426044
32. Marfori FK, Kajiyana SI, Fukusaki EI, Kobayashi A. Lansioside antibiotic from the fruit peel of *Lansium domesticum* correa. J Pharmacogn Phytochem. 2015;3(5):140-3.
33. Matsumoto T, Kitagawa T, Ohta T, Yoshida T, Imahori D, Teo S, *et al.* Structures of triterpenoids from the leaves of *Lansium domesticum*. J Nat Med. 2019;73(4):727-34. https://doi.org/10.1007/s11418-019-01319-2
PMid:31104253
34. Rudiyansyah, Alimuddin AH, Masriani, Muharini R, Proksch P. New tetranortriterpenoids, langsatides A and B from the seeds of *Lansium domesticum* Corr. (Meliaceae). Phytochem Lett. 2018;23:90-3. https://doi.org/10.1016/j.phytol.2017.11.019
35. Tsuchiya A, Makita Y, Koyano T, Kowithayakorn T, Ishibashi M, Arai MA. Isolation and evaluation of cardenolides from *Lansium domesticum* as Notch inhibitors. J Nat Med. 2020;74(4):758-66. https://doi.org/10.1007/s11418-020-01432-7
PMid:32648094
36. Zulfikar, Putri NK, Fajriah S, Yusuf M, Maharani R, Al Anshori J, *et al.* 3-hydroxy-8,14-secogammacera-7,14-dien-21-one: A new onoceranoid triterpenes from *Lansium domesticum* corr. cv kokossan. Molbank. 2020;4:1-5. https://doi.org/10.3390/M1157
37. Ramadhan R, Worawalai W, Phuwapraisirisan P. New onoceranoid xyloside from *Lansium parasiticum*. Nat Prod Res. 2019;33(20):2917-24. https://doi.org/10.1080/14786419.2018.1510395
PMid:30392392
38. Potipiranun T, Worawalai W, Phuwapraisirisan P. Lamesticumin G, a new α-glucosidase inhibitor from the fruit peels of *Lansium parasiticum*. Nat Prod Res. 2018;32(16):1881-6. https://doi.org/10.1080/14786419.2017.1354184
39. Fidiana DF, Nurullita U. Power kill the skin extract Duku (*Lansium domesticum* Corr) on death larva *Aedes aegypti*. J Kesehat Masy Indones. 2013;8(2):22-9.
40. Octaviana D, Nurlaela S, Anandari D, Pradani FY. *Lansium domesticum* Corr. leaf extract spray as bioinsecticide for *Aedes aegypti* mosquito control. Int J Public Health Clin Sci. 2020;7(2):51-9.
41. Lukitaningsih E, Saputro AH, Widiasri M, Khairunnisa N, Prabaswari N, Kuswahyuningsih R. *In vitro* antiaging analysis of topical pharmaceutical preparation containing mixture of strawberry fruit, pomelo peel, and langsat fruit extracts. Indones J Chemom Pharm Anal. 2020;1(1):53. https://doi.org/10.22146/ijcpa.603
42. Yamin Y, Ruslin R, Sabarudin S, Sida NA, Kasmawati H, Diman LO. Determination of antiradical activity, total phenolic, and total flavonoid contents of extracts and fractions of langsat (*Lansium domesticum* Coor.) Seeds. Borneo J Pharm. 2020;3(4):249-56. https://doi.org/10.33084/bjop.v3i4.1500
43. Tonolo F, Fiorese F, Moretto L, Folda A, Scalcon V, Grinzato A, *et al.* Identification of new peptides from fermented milk showing antioxidant properties: Mechanism of action. Antioxidants. 2020;9(2):117. https://doi.org/10.3390/antiox9020117
PMid:32013158
44. Yan Z, Zhong Y, Duan Y, Chen Q, Li F. Antioxidant mechanism of tea polyphenols and its impact on health benefits. Anim Nutr. 2020;6(2):115-23. https://doi.org/10.1016/j.aninu.2020.01.001
PMid:32542190
45. Baschieri A, Amorati R. Methods to determine chain-breaking antioxidant activity of nanomaterials beyond dpph: A review. Antioxidants. 2021;10(10):1-21. https://doi.org/10.3390/antiox10101551
46. Ji KL, Dai MY, Xiao CF, Xu YK. Two new steroids with NO inhibitory effects from *Lansium domesticum*. Nat Prod Res. 2021;35(7):1147-52. https://doi.org/10.1080/14786419.2019.1643862
PMid:31315445
47. Manosroi A, Kumguan K, Chankhampan C, Manosroi W, Manosroi J. Nanoscale gelatinase A (MMP-2) inhibition on human skin fibroblasts of longkong (*Lansium domesticum* Correa) leaf extracts for anti-aging. J Nanosci Nanotechnol. 2012;12(9):7187-97. https://doi.org/10.1166/jnn.2012.6500
PMid:23035451
48. Alfonso ED, Fernando SI, Pineda PS, Divina CC. Antibacterial activity and genotoxicity assays of lanzones (*Lansium domesticum*) seeds extract. Int J Agric Technol. 2017;13(7-3):2427-34.
49. Umair TP, Wijaya F, Ernanto JH, Parulian T. The effect of *Lansium domesticum* Corr duku extract on wound healing. 2020;8-11.
50. Nurhamidin AP, Antasionasti I. Antibacterial activity test of

n-hexane extract of langsat fruit SEEDS (*Lansium domesticum* Corr) against *Staphylococus aureus* and *Klebsiella pneumoniae* bacteria uji aktivitas antibakteri ekstrak n-heksan biji buah langsat (*Lansium domesticum* Corr) TER. 2021;10:32772. https://doi.org/10.35799/pha.10.2021.32772

51. Abotaleb M, Liskova A, Kubatka P. Therapeutic potential of plant phenolic acids in the treatment of cancer. Biomolecules 2020;10:221. https://doi.org/10.3390/biom10020221
PMid:32028623
52. Mazalovska M, Kouokam JC. Review article plant-derived lectins as potential cancer therapeutics and diagnostic tools. Biomed Res Int. 2020;2020:1631394. https://doi.org/10.1155/2020/1631394
53. Kiskova T, Kubatka P, Büsselberg D. The plant-derived compound resveratrol in brain cancer: A review. Biomolecules. 2020;10(1):161. https://doi.org/10.3390/biom10010161
PMid:31963897
54. Manosroi A, Jantrawut P, Sainakham M, Manosroi W, Manosroi J. Anticancer activities of the extract from Longkong (*Lansium domesticum*) young fruits. Pharm Biol. 2012;50(11):1397-407. https://doi.org/10.3109/13880209.2012.682116
PMid:22849519
55. Manosroi A, Chankhampan C, Manosroi W, Manosroi J. Anti-proliferative and matrix metalloproteinase-2 inhibition of Longkong (*Lansium domesticum*) extracts on human mouth epidermal carcinoma. Pharm Biol. 2013;51(10):1311-20. https://doi.org/10.3109/13880209.2013.790064
PMid:23763335
56. Purwani S, Nahar J, Zulfikar Z, Nurlelasari N, Mayanti T. Molecular docking on kokosanolide A and C for anticancer activity against human breast cancer cell MCF-7. J Kim Val. 2021;7(1):52-7. https://doi.org/10.15408/jkv.v7i1.20534
57. Khalili RM, *et al.* Cytotoxicity effect and morphological study of different duku (*Lansium domesticum* corr.) extract towards human colorectal adenocarcinoma cells line (HT-29). Pharmacogn J. 2014;9(6):757-61. https://doi.org/10.5530/pj.2017.6.119
58. Fadhilah K, Wahyuono S, Astuti P. A sesquiterpene aldehyde isolated from ethyl acetate extract of *Lansium domesticum* fruit peel. Indones J Pharm. 2021;32(3):394-8. https://doi.org/10.22146/ijp.1884
59. Bello OA, Ayanda OI, Aworunse OS, Olukanmi BI. Can medicinal properties of watercress be relevant to human health? A systematic review based on preclinical study *in vivo*. Pharmacogn Rev. 2018;1(2):8-15. https://doi.org/10.4103/phrev.phrev
60. Yang W, Chen X, Li Y, Guo S, Wang Z, Yu X. Advances in pharmacological activities of terpenoids. Nat Prod Commun. 2020;15(3):355. https://doi.org/10.1177/1934578X20903555
61. Thoppil RJ, Bishayee A. Terpenoids as potential chemopreventive and therapeutic agents in liver cancer. World J Hepatol. 2011;3(9):228-49. https://doi.org/10.4254/wjh.v3.i9.228
PMid:21969877
62. Bergman ME, Davis B, Phillips MA. Occurrence, and mechanism of action. Molecules: 2019;24(21):1-23.