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Traditional Uses, Biological Activities, and Phytochemical Profile of Keji Beling (*Strobilanthes crispus)* Leaf Extract: A Review

[Penggunaan Tradisional, Aktivitas Biologis, dan Profil Fitokimia Ekstrak Daun Keji Beling (*Strobilanthes crispus*): Sebuah Tinjauan]

Yeli Sukendi[1], Mohamad Rafi[1,2], Dea Silviani[1], Wulan Tri Wahyuni[1,2]*

[1]*Department of Chemistry, Faculty of Mathematics and Natural Sciences, IPB University, Bogor, West Java, 16680, Indonesia*
[2]*Tropical Biopharmaca Research Center, IPB University, Bogor, West Java, 16128, Indonesia*

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ABSTRACT

Health treatment in Indonesia is diverse, encompassing both modern medicine using synthetic drugs and traditional practices relying on herbal plants. Traditional medicine is often preferred due to its lower cost and perceived lack of side effects. Keji beling (*Strobilanthes crispus*) is one such herb with potential medicinal properties. This article summarizes information regarding traditional uses, biological activities, phytochemical profiles, and active compounds of keji beling leaf extract. Traditionally, keji beling leaves are consumed as tea. The plant has demonstrated antioxidant, anti-diabetic, anticancer, antitumor, and antibacterial properties. These biological effects are attributed to its phytochemical constituents, including flavonoids, alkaloids, saponins, tannins, and terpenoids. Specific bioactive compounds in keji beling leaf extract comprise silicic acid, polyphenols, glycosides, catechins, rutin, epicatechin, myricetin, luteolin, apigenin, naringenin, and kaempferol.

ABSTRAK

Jenis pengobatan yang digunakan oleh masyarakat Indonesia sangat beragam, mulai dari pengobatan medis dengan obat-obatan sintetik hingga pengobatan tradisional yang menggunakan tanaman herbal. Belakangan ini, pengobatan tradisional lebih disukai karena cenderung memiliki efek samping yang rendah dan harga yang lebih terjangkau. Salah satu tanaman yang berpotensi sebagai obat herbal adalah keji beling (*Strobilanthes crispus*). Pada artikel ini disampaikan hasil telaah literatur mengenai penggunaan tradisional, aktivitas biologis, profil fitokimia, dan senyawa aktif dari ekstrak daun keji beling. Penggunaan tradisional dari daun keji beling dilakukan dengan cara direbus atau diseduh sebagai teh. Aktivitas biologis daun keji beling berdasarkan riset yang dilaporkan meliputi antioksidan, antidibetes, antikanker, antitumor, dan antibakteri. Aktivitas biologi tersebut berkaitan dengan profil fitokimia ekstrak daun keji beling yang berasal dari golongan flavonoid, alkaloid, saponin, tanin, dan terpenoid. Sementara itu, senyawa bioaktif yang dilaporkan terkandung dalam ekstrak daun keji beling adalah asam silikat, polifenol, glikosida, katekin, rutin, epikatekin, mirsetin, luteolin, apigenin, naringenin dan kaempferol.

*Corresponding author:
Wulan Tri Wahyuni (wulantriws@apps.ipb.ac.id)

1. INTRODUCTION

Indonesian people have increasingly turned to traditional medicine in recent years. According to the Indonesian Ministry of Health, spending on traditional medicines via e-catalogs has steadily risen (Ministry of Health, 2023). Moreover, Indonesia has abundant natural resources of medicinal plants with potential to treat various diseases, stimulating growth in the herbal medicine industry. One such promising plant is *Strobilanthes crispus*, commonly known as keji beling, which belongs to the Acanthaceae family (Suproborini *et al.*, 2020; Silalahi, 2020). Also referred to as keci beling, pecah beling (Betawi dialect), or enyoh kelo (Javanese), local communities often consume decoction of keji beling leaves to address various ailments (Tamu *et al.*, 2020).

The annual growth rate of the keji beling plant reaches 6.24% and its potential use as a herbal medicine continues to increase (Isrianto 2017). The primary part of the keji beling plant used for medicinal purposes is the leaves. Traditionally, keji beling leaf preparations have been employed to address various health conditions, including kidney stones, gallstones, diabetes, cholesterol, tumors, and cancer (Chua *et al.* 2019). In general, keji beling leaf extract is reported to exhibit several biological activities, including antioxidant (Ghasemzadeh *et al.*, 2015), antibacterial (Adibi *et al.*, 2017), antimicrobial (Suboh *et al.*, 2022), antitumor (Baraya *et al.*, 2020), and anticancer effects (Roring *et al.*, 2017; Guan Ng *et al.*, 2021). The biological activities of keji beling leaf extract are closely related to the chemical components present in the leaves.

Keji beling plant is known to contain polyphenolic compounds, caffeine, saponins, alkaloids, flavonoids, tannins, β-sitosterol, and stigmasterol (Setyawan *et al.* 2016). Among these compounds, tannins and flavonoids have the potency to act as antioxidants, antimicrobials and improve the immune system. According to Henhena *et al.* (2015), keji beling leaves have high antioxidant activity due to the presence of phenolic compounds, such as caffeic acid, ferulic acid, kaempferol, and luteolin. Public knowledge about the chemical composition of keji beling leaves remains limited. Consequently, there is a need for comprehensive research on the plant's chemical constituents. This review aims to provide a foundation for future studies by compiling information on the traditional use, biological activities, phytochemical profile, and active compounds of keji beling leaf extract.

2. METHOD

This review employed a systematic search strategy to identify relevant primary research articles, books, and national/international journals published within the past 10 years. Trusted scientific databases including Google Scholar, Scopus, ScienceDirect, PubMed, and the Royal Society of Chemistry database were utilized for article and journal retrieval. Additionally, relevant information was sought from books, theses, and other scientific publications. Keywords employed in both Indonesian and English versions included: biological activity, anticancer, antioxidant, antidiabetic, antitumor, antibacterial, keji beling (*Strobilanthes crispus*), phytochemicals, alkaloids, flavonoids, saponins, tannins, and terpenoids. Identified articles and journals were then rigorously evaluated and selected based on their relevance to the research topic.

Data were extracted from scientific articles and journals and organized into three primary sections: 1) traditional uses of keji beling leaf extract, 2) biological activities of keji beling leaf extract, and 3) phytochemical profile and active compounds of keji beling leaf extract. A narrative analysis was employed to synthesize the information and categorize findings according to each section. Conclusions were derived from a comprehensive review of scientific literature pertaining to the traditional use, biological activities (including anticancer, antitumor, antibacterial, and other properties), phytochemical profile, and active compounds of keji beling leaf extract.

3. RESULT AND DISCUSSION

3.1. Traditional Uses of Keji Beling Leaf Extract

Keji beling (*Strobilanthes crispus*) is a wild shrub commonly found in tropical regions, ranging from Madagascar to the Malay Archipelago. As depicted in Figure 1, this plant typically grows to a height of 1-2 meters and features single, oval leaves with serrated edges. Both the leaf tip and base are tapered, with leaf dimensions measuring 9-18 centimeters in length and 3-8 centimeters in width. The plant has short and green stems (Suproborni *et al.*, 2020). This plant commonly referred to as "daun pecah beling" in Betawi, "enyoh kelo," "keci beling," or "keji beling" in Javanese, and "bayam karang," "persik beling," "jin batu," or "pecah kaca" in Malay, keji beling is also known as "Hei Mian Jiang Jun" (Black-Faced General) in Chinese. The following is the plant's classification:

Kingdom : *Plantae*
Division : *Magnoliophyta*
Class : *Mognoliopida*
Order : *Scrophulariales*
Family : *Acanthaceae*
Genus : *Strobilantes*
Spesies : *Strobilathes crispus*

Keji beling can thrive both as a wild plant and as a cultivated species. This plant has been traditionally used by Indonesians, Malaysians, and Chinese populations as medicinal properties for centuries (Suyanti *et al.*, 2013). Keji beling leaves have been employed to treat a wide range of ailments, including kidney stones, diabetes, ulcers, diarrhea (Kustini and Susila, 2019), cancer, asthma, tumors, hemorrhoids, constipation, and diabetes (Fitriana *et al.*, 2017). Traditional preparation methods often involve boiling the leaves and consuming the resulting decoction (Liza *et al.*, 2012). In addition, Chinese communities have incorporated keji beling leaves into herbal teas to address diuretic issues, diabetes, and constipation. Interestingly, indigenous populations in Perak, Malaysia, have adopted a different

approach, consuming fresh leaves directly to enhance immune function (Cheong *et al.*, 2016). Table 1 provides a summary of these traditional uses, which are based on empirical knowledge rather than clinical trials.

3.2. Phytochemical Profile and Active Compound of Keji Beling Leaf Extract

Keji beling leaf extract contains a diverse array of phytochemicals, including flavonoids, alkaloids, saponins, steroids, terpenoids, and tannins (Table 2). These compounds collectively contribute to the biological activities of the extracts. Flavonoids, in particular, have been implicated in a range of pharmacological effects, such as antioxidant, antidiabetic, antibacterial, antitumor, and anticancer properties (Parubak, 2013). Kaempferol (Figure 2a) is one example of a flavonoid identified in keji beling leaf extract (Rompas *et al.*, 2012). Solvent selection for flavonoid extraction should consider the principle of "like dissolves like," meaning a solvent with similar polarity to the target compound is generally preferred.

Alkaloids are secondary metabolites commonly found in plant tissues, including leaves, stems, and fruits. Often characterized by a bitter and astringent taste, alkaloids typically contain one or more nitrogen atoms within a heterocyclic ring structure (Hammado & Illing, 2013). The nitrogen moiety contributes to the alkaloid's biological activities, such as antibacterial properties. While keji beling (*Strobilanthes crispus*) leaves have been reported to contain alkaloids (Fardiyah, 2020), specific alkaloid compounds have yet to be isolated and characterized from this plant.

Figure 1. *Strobilanthes crispus*. Source: https://www.halodoc.com/

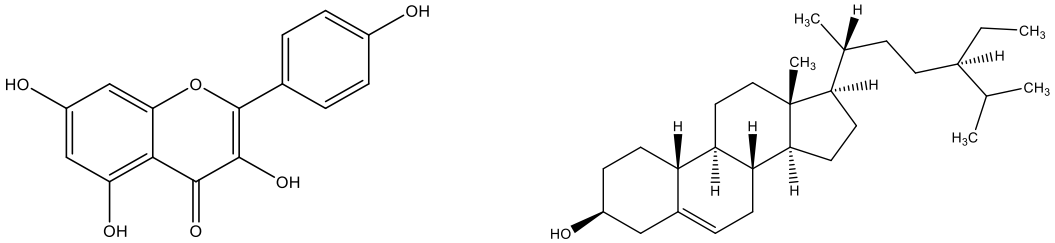
Saponins have demonstrated antidiabetic properties, particularly for type 2 diabetes (Arora *et al.*, 2024). Saponins from plants have been reported to inhibit blood glucose increases by reducing glucose absorption in the small intestine and delaying stomach emptying (Minarno, 2016). Additionally, they can inhibit the alpha-glucosidase enzyme and stimulate insulin production (Arora *et al.*, 2024). Beyond their antidiabetic effects, saponins have antibacterial properties, often in combination with other active compounds like flavonoids and alkaloids. The antibacterial mechanism of saponins involves disrupting the stability of bacterial cell membranes, leading to cell death (Romas *et al.*, 2015).

Table 1. Tradisional uses of Keji Beling

No	Area	How to use	Plant part	The type of deseases	Reference
1.	Indonesia and Malaysia	leaf, brewed and drink	leaf	Diabetes, kidney stones, diarrhea laxative	Liza *et al.* 2012
2.	China, Malaysia, and Indonesia	leaf, boiled and drink	leaf	Diabetes and constipation	Ghasemzadeh *et al.* 2015
3.	Perak, Malaysia	Fresh leaf, chewed	leaf	Improve the immune system	Cheong *et al.* 2016

Table 2. Phytochemical constituent in keji beling extract

No	Compound	n-hexane (Gul *et al.* 2020)	Ethyl acetate (Gul *et al.* 2020)	Methanol (Gul *et al.* 2020)	Aqueous (Gul *et al.* 2020)	Methanol (Fardiyah *et al.* 2020)
1.	Flavonoid	N.A	N.A	N.A	N.A	+
2.	Alkaloid	+	+	-	-	+
3.	Saponin	-	-	+	+	+
4.	Steroid	-	+	+ +	+	+
5.	Terpenoid	-	+	+ +	+	+
6.	Tanin	+	-	+	+	+



(a) (b)

Figure 2. Secondary metabolite from keji beling leaf (a) kaempherol and (b) β-sitosterol

Terpenoids are lipophilic compounds and are among the largest classes of secondary metabolites. These compounds are composed of isoprene units, each containing five carbon atoms (-C5), and are synthesized from acetate via the mevalonic acid pathway. Terpenoids exhibit a diverse range of structures, from linear to polycyclic molecules, and can vary greatly in size, from hemiterpenes with five carbon units to those with thousands of isoprene units. Notable terpenoids identified in keji beling extract include β-sitosterol (Figure 2b) and limonene (Sulastri *et al.*, 2021). Terpenoids in keji beling leaf extract are known for various biological activities, including anticancer effects (Sulastri *et al.*, 2021). Additionally, keji beling leaf extract contains tannins, which have potential antidiarrheal and antibacterial properties (Susanto and Wantenia, 2020).

Rivai *et al.* (2015) conducted quantitative analyses to determine the levels of phenolic compounds, tannins, alkaloids, and flavonoids in hexane, acetone, ethanol, and water extracts of keji beling leaves. Flavonoid content was measured spectrophotometrically using an aluminum chloride reagent at 430 nm, with quercetin as a standard. Ethanol extract exhibited the highest flavonoid levels. Phenolic compound content was assessed spectrophotometrically using the Folin-Ciocalteu reagent at 732 nm, with the acetone extract demonstrating the highest average phenol content. Alkaloid content was determined gravimetrically by isolating alkaloids using chloroform. The dried alkaloid residue was weighed, with the acetone extract yielding the highest alkaloid levels. Tannin content was measured spectrophotometrically at 279.80 nm using catechin as a standard, and the ethanol extract showed the highest tannin content (**Table 3**).

Table 3. Phytochemical content of keji beling leaf extracts (Rivai *et al.* 2015)

No	Compound	Solvent	Content (%)
1.	Flavonoid	ethanol	1.333
		aqueous	0.954
2.	Phenolic	acetone	1.026
		ethanol	0.773
		aqueous	0.425
3.	Alkaloid	acetone	0.721
		ethanol	0.643
4.	Tannin	acetone	0.711
		ethanol	1.319

Liza *et al.* (2010) identified eight compounds in keji beling leaf extract using high-performance liquid chromatography (HPLC), namely catechin, epicatechin, rutin, myricetin, luteolin, apigenin, naringenin, and kaempferol. In contrast, Ghasemzadeh *et al.* (2015) reported high flavonoid levels, specifically 44.0 mg equivalent to quercetin, through chromatographic analysis. Cheong *et al.* (2016) employed GC-MS with methanol extraction to analyze keji beling leaf extract's secondary metabolites (Table 4). These compounds are believed to contribute to the plant's biological activity. Koh *et al.* (2017) further characterized the extract, reporting polyphenolic compounds, polar vitamins, caffeine, and catechins. Meanwhile, Rezki *et al.* (2016) identified silicic acid, glycosides, and vitamins C, B1, and B2 in the keji beling plant and Roring *et al.* (2017) expanded on the extract's composition, including alkaloids, saponins, terpenoids, and tannins.

3.3. Biological Activities of Keji Beling Leaf Extract

Keji beling leaf extract is widely used as a herbal remedy due to its efficacy in treating various ailments. This is attributed to the presence of secondary metabolite compounds within the extract. Research has documented the diverse biological activities of keji beling leaf extract, including antioxidant (Rompas, 2021), antidiabetic (Palit *et al.*, 2018), anticancer (Yacoob *et al.*, 2014), antitumor (Yacoob *et al.*, 2015), antibacterial (Adibi *et al.*, 2017), and cytotoxic properties (Endrini *et al.*, 2014). The following section will elaborate on these various biological activities.

3.4. Antioxidant Activity

Antioxidants are compounds that donate electrons or hydrogen atoms to prevent, delay, or slow down the formation of harmful free radicals in the human body. Natural antioxidants, commonly found in plants, include phenolic compounds, flavonoids, cinnamic acid derivatives, coumarins, tocopherols, and polyfunctional organic acids (Simanjuntak, 2012). Keji beling leaves are known for their antioxidant properties, primarily attributed to their flavonoid content (Apriliani & Tukiran, 2021). The hydroxyl groups in the molecular structure of flavonoids contribute to their antioxidant activity. Additionally, the prenyl group ($(CH_3)_2C=CH\text{-}CH_2$) within flavonoids has been investigated for its potential in preventing diseases related to free radicals (Simanjuntak, 2012).

Table 4. Content of keji beling leaf extract based on GC-MS analysis (Cheong *et al.* 2016)

No.	Compound	Content (%)
1.	13-tetradecene-11yn-1-ol	0.46
2.	9,12,15- octadecatrienoic acid, (Z,Z,Z)-	26.21
3.	9-octadecenamiea, (Z)-	0.01
4.	6-tetradecanesulphonic acid, butyl ester	0.24
5.	Hexadecanoic acid, 2-hydroxy-1-(hydroxyimethil)ethyl ester	1.05
6.	Eicosane	0.30
7.	cyclododecyne	1.05
8.	Squalene	26.11
9.	2-Methyl-3-(3-methyl-but-2-enyl)-2-(4-methyl-pent-3-enyl)-oxetane	0.17
10.	Gamma-Tocopherol	0.34
11.	cholesterol	1.96
12.	Vitamin E	9.75
13.	campesterol	3.57
14.	Stigmasterol	10.93
15.	Gamma-sitosterol	6.70
16.	Beta-amyrin	1.47

The antioxidant activity of keji beling leaf extract can be assessed using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method. This

method is based on the principle that antioxidants in the extract donate hydrogen atoms to DPPH, causing a color change from purple to yellow and a decrease in absorbance at the maximum DPPH wavelength (Budilaksono et al., 2014). By measuring absorbance with a UV-Vis spectrophotometer, the free radical scavenging activity can be quantified and expressed as the IC_{50} value. An IC_{50} value below 50 ppm indicates a very strong antioxidant, 50-100 ppm indicates a strong antioxidant, 101-150 ppm indicates a moderate antioxidant, and 150-200 ppm indicates a weak antioxidant (Molyneux 2004 in Widyasanti *et al.*, 2016).

Table 5 presents the IC_{50} values for the ethanol extract of keji beling leaves determined using the DPPH method. The ethanol extract is classified as a strong antioxidant based on the findings of Rompas (2021) and Apriliani and Tukiran (2021). However, Adibi *et al.* (2017) reported a moderate antioxidant activity for the ethanol extract. These results collectively indicate the potential of the ethanol extract of keji beling leaves as an antioxidant due to its ability to scavenge DPPH free radicals. Beyond the DPPH method, the Ferric Reducing Antioxidant Power (FRAP) method can also be employed for assessing the antioxidant capacity of keji beling leaf extract (Ghasemzadeh *et al.*, 2015).

3.5. Antidiabetic Activity

Diabetes is a chronic disorder of glucose metabolism characterized by elevated blood glucose levels, or hyperglycemia (Okaiyeto *et al.*, 2021). Unhealthy eating habits and accumulation of blood glucose, are contributing factors to diabetes. In Indonesia, several plants with potential medicinal properties for diabetes treatment have been identified, including the keji beling, which has been reported to possess anti-diabetic activity. Key chemical components in this plant which contribute to its anti-diabetic effects are saponins and steroids, as they can inhibit glucose absorption and prevent increases in blood glucose levels (Minarno, 2016). Research by Palit *et al.* (2018) demonstrated that the ethanol extract of keji beling leaves significantly reduced blood sugar levels in *Rattus norvegicus*. The highest dose administered, 300 mg/kg BW, resulted in a 31.66% reduction in blood sugar levels.

Testing of the antidiabetic activity of keji beling leaf extract was determined based on its effect in reducing blood glucose levels. According to Nurhidayah *et al.* (2015), antidiabetic activity can be assessed by administering various doses of the extract to white mice. Prior to testing, keji beling leaves are extracted using the maceration method with an ethanol solvent for 3 days. Blood glucose reduction is measured by monitoring the average decrease in blood glucose levels over time. The tested extract doses were 50 mg/kgBW, 100 mg/kgBW, and 150 mg/kgBW, all of which were reported to reduce blood glucose levels (Table 6). The most effective dose was 150 mg/kgBW, as it resulted in the greatest reduction in blood glucose levels at 120 minutes.

Table 5. Antioxidant activity of ethanol extract of keji beling leaf

No	Method	Solvent	Part of plant	IC50 (ppm)	References
1.	DPPH	Ethanol	Leaf	102.85	Adibi *et al.* 2017
2.	DPPH	Ethanol	Leaf	71.39	Apriliani dan Tukiran 2021
3.	DPPH	Ethanol	Leaf	47.79	Rompas 2021

The antidiabetic activity of keji beling leaf extract can also be assessed by evaluating its ability to inhibit α-amylase and α-glucosidase enzymes *in vitro*. Devi *et al.* (2019) investigated the inhibitory effects of a keji beling leaf water extract on these enzymes. The extract was prepared by extracting keji beling leaves with 100 mL of water, using 50 mL of fresh keji beling leaf extract. For the α-amylase activity inhibition test, the starch substrate was hydrolyzed into maltose using the 3,5-Dinitrosalicylate (DNS) reagent, which produced a color change from yellow to orange. Absorbance was then measured. In the α-glucosidase enzyme activity inhibition test, p-nitrophenyl-α-D-glucopyranoside was used as the substrate, and the yellow color formed from p-nitrophenyl was measured for absorbance. The results indicated that the water extract of keji beling leaves exhibited a high percent inhibition of α-amylase, at 99.79 ± 6.92%. This effect is attributed to the presence of steroids and saponins in the extract. Conversely, the inhibition of the α-glucosidase enzyme by the sample infusion was relatively modest, at 26.44 ± 1.13%. The presence of steroid and saponin compounds is thought to contribute to the inhibition of α-amylase and α-glucosidase enzymes due to their known hyperglycemic activity and their ability to stimulate insulin release.

Table 6. Glucose reduction caused by keji beling leaf extracts

No	Solvent	Method	Dose (mg/kgBW)	Glucose reduction	References
1.	Ethanol	*In vivo*	300	31.66%	Palit *et al.* 2018
2.	Ethanol	*In vivo*	50	141.30 mg/dL	Nurhidayah *et al.* 2015
			100	126.67 mg/dL	
			150	148.70 mg/dL	

3.6. Anticancer Activity

Cancer is a disease characterized by the growth of abnormal cells in body tissues that have undergone mutations and changes in biochemical structure (Wijaya and Muchtaridi, 2017). To combat cancer, effective treatments are needed to neutralize and prevent its progression. However, commercial cancer treatments can be costly and often have severe side effects, highlighting the need for alternative herbal medicines that may serve as anticancer agents. The keji beling plant, particularly its leaves, has been reported to possess anticancer potential. Extracts from keji beling leaves have demonstrated efficacy against various types of cancer, including

colorectal cancer (Al-Henhena *et al.*, 2015), breast cancer (Roring *et al.*, 2017), and liver cancer (Baraya *et al.*, 2019).

The anticancer potential of keji beling leaf extract can be assessed using the 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) method. Previous research has demonstrated the anticancer properties of keji beling leaf extracts. Ismail *et al.* (2012) reported that ethyl acetate and methanol extracts exhibited anticancer activity against colon cancer cells (HT-29), while Gordani *et al.* (2017) found that methanol, chloroform, and water extracts inhibited the growth of breast cancer cells (MCF-7). Both studies employed the MTT method to evaluate anticancer activity. According to Gordani *et al.* (2017), the water extract displayed very strong anticancer properties, while the methanol and chloroform extracts exhibited strong anticancer effects (Table 7).

3.7. Antitumor Activity

A tumor is an abnormal lump that can grow uncontrollably in the body. Tumors can be either malignant or benign, and if not treated early, they can lead to severe health consequences. Tumor disease is reported as one of the leading causes of death worldwide (Kristian *et al.*, 2021). Treatment for tumors often involves administering antitumor substances. Research by Yacoob *et al.* (2015) investigated the effects of keji beling leaf extract on a mouse mammary tumor model induced by N-methyl-N-nitrosourea (NMU). Mice were treated with extracts combined with dichloromethane, resulting in a significant reduction in average tumor volume. Analysis of the dichloromethane extract revealed the presence of lutein, 13^1-hydroxy-13^2-oxo-pheophytin, campesterol, stigmasterol, β-sitosterol, pheophytin, and 13^2-hydroxy-pheophytin (Table 8).

3.8. Antibacterial Activity

Keji beling leaf extract is known for its antibacterial properties against various types of bacteria. Rawung *et al.* (2019) reported that keji beling leaf extract, obtained through maceration with 80% ethanol, exhibits antibacterial activity. This activity was measured by the diameter of the inhibition zone, with keji beling leaf extract showing a mean inhibitory zone diameter of 1.6 mm. In comparison, amoxicillin demonstrated a larger inhibitory zone diameter of 2.72 mm (Table 9). Although the inhibition zone diameter of keji beling leaf extract is smaller than that of amoxicillin, it has still been proven effective in inhibiting the growth of *Streptococcus pyogenes*. Additionally, Artanti and Fatimah (2017) found that keji beling leaf juice can inhibit the growth of *Staphylococcus aureus*. The antibacterial activity of keji beling leaf juice is attributed to its active compounds, including flavonoids, saponins, and alkaloids.

3.9. Cytotoxic Activity

The cytotoxic activity of keji beling leaf extract was tested as an initial evaluation of its potential anticancer properties. Research by Itam *et al.* (2015) reported the cytotoxic effects of several keji beling leaf extracts using the brine shrimp lethality test (BSLT) method. The cytotoxic effect can be determined by the LC_{50} value of the keji beling extract. If the LC_{50} is less than 100 mg/L then it is categorized as having strong cytotoxic properties, if the value ranges between 100-500 mg/L it is categorized as moderate cytotoxic, and if the LC_{50} value is between 500-1000 mg/L then it is classified as having weak cytotoxic properties, whereas if more than 1000 mg/L is categorized as non-toxic. The methanol extract of keji beling leaves had the strongest cytotoxic effect because it had an LC_{50} value as high as that of the other extracts, while the ethyl acetate, hexane and water extracts showed moderate cytotoxic properties (Table 10). Endrini *et al.* (2015) reported the cytotoxic effect of chloroform extract of keji beling leaves on several human cancer cells, including colon carcinoma cells (Caco-2), liver cancer cells (HepG2), breast cancer cells (MCF-7), and Hela cells. The results obtained showed that the cytotoxic effect of keji beling extract on HepG2 and MCF-7 cells (expressed as LC_{50}) was 21.8 and 28.8 mg/mL, respectively. The LC_{50} value for Caco-2 cells was 83.3 mg/mL and the LC_{50} value for Hela cells was >100 mg/mL. This shows that the chloroform extract of keji beling leaves has a strong cytotoxic effect on HepG2, MCF-7 and Caco-2 cells, and a moderate cytotoxic effect on Hela cells.

Table 7. Potency of keji beling leaf extracts as anticancer

No	Method	Solvent	Cancer cell	IC_{50} (µg/mL)	References
1.	MTT	Ethyl acetate	HT-29	70.2	Ismail *et al.* 2012
		Methanol	HT-29	59	
2.	MTT	Methanol	MCF-7	74	Gordani *et al.* 2017
		Chloroform	MCF-7	80	
		Water	MCF-7	23	

Table 8. The effect of keji beling leaf extract treatment on reducing tumor volume

No	Solvent	Tumor model	Result	Active compound	References
1.	Dichloromethane	NMU induced mice mammary tumor	Tumor volume reduction	Lutein, purpurin-7-methyl phytyl ester, pheophytin a, and 13^2-hydroxy-pheophytin a, campesterol, stigmasterol, β-sitosterol	Yacoob *et al.* 2015
2.	Dichloromethane	NMU induced mice mammary tumor	Tumor volume reduction	Not mentioned	Yankuzo *et al.* 2018

Table 9. Antibacterial activity of keji beling leaf extracts

No	Bacteria	Extraction solvent	Antibacterial activity	Reeferences
1.	*Streptococcus pyogenes*	Ethanol 80%	Inhibition zone diameter 1.6 mm	Rawung *et al.* 2019
2.	*Staphylococcus aureus*	Water	No bacteria grow in extract concentration of 75%	Artanti dan Fatimah 2017

Table 10. Cytotoxic effect of keji beling leaf extracts

No	Method	Extraction solvent	LC50 (mg/mL)	Cytotoxic effect	References
1.	Brine Shrimp (*Artemia salina*)	Methanol	25.67	Strong	Itam et al. 2015
		Ethyl acetate	240.96	Medium	
	Caco-2 cell	Hexane	302.36	Medium	
	HepG2 cell	Water	402.72	Medium	
2.	MCF-7 cell	Chloroform	83.3	Strong	Endrini et al. 2015
	Hela cell		21.8	Strong	
			28.8	Strong	
			>100	Medium	

4. CONCLUSION

Keji beling leaf extract (*Strobilanthes crispus*) is used by the community as a herbal remedy, typically consumed by boiling or brewing it as tea. This is due to its various biological activities, including antioxidant, antidiabetic, anticancer, antitumor, antibacterial, and cytotoxic effects. The diverse biological activities of keji beling leaves are attributed to several groups of phytochemical compounds, such as flavonoids, tannins, alkaloids, saponins, steroids, and terpenoids

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