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The phytochemical constituents and pharmacological properties of *Munronia pinnata*: A review

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Abstract
Munronia pinnata is a rare perennial medicinal herb widely used in Sri Lanka, China and India. It belongs to the family Meliaceae, which has many ecotypes in leaflets such as 3,5,7,9 and 11. *Munronia pinnata* has been used in an array of diseases like fever, general pain, haemorrhoids, dysentery, eczema, cough, asthma, oedema, circulatory disorders, malaria, and vomiting. Despite its long history of use in traditional medicine in Sri Lanka, only a very few research and scientific publications have been recorded. Therefore, this review provides a robust knowledge of available scientific facts on *Munronia pinnata*. *Munronia pinnata* was proved to possess following pharmacological properties; hypoglycemic, antioxidant, anti-inflammatory, antibacterial, antifungal, antimalarial, hepatoprotective and antivenom. The available *in-vivo* and *in-vitro* suggests that *Munronia pinnata* have effective pharmacological properties which can be used to identify lead molecules from the plant. However, an extensive study of medicinal properties of *Munronia pinnata* is necessary to identify the mechanisms of the properties exhibited by the plant and utilize their valuable medicinal properties.

Keywords: *Munronia pinnata*; phytochemical; pharmacological; hypoglycemic; anticancer

1. Introduction
*Munronia pinnata*is a rare medicinal plant belonging to the Meliaceae family. It has a short stem with compound leaves hovering on a hard stem. The number of leaflets found in a leaf varies between 3, 5, 7, 9, or 11(Figure 1). *Munronia pinnata* is naturally present in China, India, Vietnam, Indonesia, Malaysia, Philippines, and Sri Lanka [1]. This plant grows in various ecosystems, including rocky areas in the arid, central and humid regions of Sri Lanka [1]. Medicinal plants have produced various phytochemicals or secondary metabolites and have been used for several purposes, such as food preservatives, flavourings, and the treatment of multiple diseases. It is known that growing this plant is economically beneficial. The plant is an endemic herb of South Asia and an endangered plant of the family. Indigenous medicine in Sri Lanka uses the *Munronia pinnata* for various formulas. The whole plant can use as a fresh juice, a powder of dried plant, a water infusion, a paste and as a decoction to treat fever, general pain, haemorrhoids, dysentery, eczema, cough, asthma, oedema, circulatory diseases, malaria, and vomiting [2, 3]. Nevertheless, *Munronia pinnata* is also used to treat tuberculosis, cough, stomachache, and sores in Traditional Chinese medicine [4].
In Sri Lanka, the demand for this herb is very high and, therefore, costly to obtain. Due to the increased demand, wild stock of *Munronia pinnata* has been depleted. It is listed as one of the fifty most important medicinal plants in Sri Lanka as it is classified as the most precious and rarest endangered plant [5]. This medicinal plant's unit price is the highest at around the U.S. $ 50-1104 per kilogram in traditional systems of medicine in Sri Lanka. If this demand continues to rise, the plant will soon be extinct from its natural habitat [1].
Since herbal medicines have few/no side effects, herbal medicines are gradually gaining popularity in both developing and developed countries. The use of a multi-component system and acceptable analytical methods for quality assessment of herbal materials' safety and effectiveness is essential because it can enhance their quality, safety, and effectiveness [6]. In Ayurvedic Pharmacopeia (Sri Lanka), the entire plant of *Munronia pinnata*is used as the major ingredient of preparations used for the above ailments. Since herbal medicine is gradually getting popular among people in both developing and developed countries due to its less /no adverse effects, it is a timely important herbal plant to acknowledge the previous research data and design different studies to fill the loopholes on the knowledge on one of the most expensive and valuable plants in Sri Lanka.
Despite its long record of usage in indigenous clinical practices, there is available information on comparative pharmacognostic, physicochemical, phytochemical and antioxidant capacity of

this herb. Therefore, this review focuses on the importance and the research done on the herbal plant *Munronia pinnata*, which has an exceptional therapeutic value.

Fig 1: Munronia pinnata plant. (a) Five leaflet ecotype (b) flowers from three leaflet ecotype.

2. Methodology

In the first phase, a comprehensive literature search was carried out in the following databases: PubMed Central (PMC) ® (U.S. National Library of Medicine, USA), Ovid © (Ovid Technologies, Inc.) Science Direct © (Elsevier B.V), Springer Link © (Springer Nature Switzerland AG), Cochrane Library © (John Wiley & Sons, Inc.), and Google Scholar. The keyword used was: "*Munronia pinnata*". The results were limited to studies in English, while all the published articles regarding *Munronia pinnata* were included.

The total number of hits obtained when searching the database using the above search criteria is combined, and duplicate articles were deleted. The articles were checked by reading the full text for the following information: Phytochemical properties, pharmacological properties, and ethno pharmacological data on venom treatment of *Munronia pinnata*. Studies that do not meet the inclusion criteria are excluded at these stages.

In the final step, to obtain more data, a manual search was performed using the reference list of the included articles. When possible, follow up on the citations of the studies were done during the literature review and checked whether if it is possible to include them. The search process was carried out independently by two reviewers, and after repeated consensus processes, the final group of articles to be included in the review was determined [7].

The literature search using the above search criteria identified the following number of articles in the respective databases; PubMed Central (n=7), Ovid (n=10), Science Direct (n=15), Springer Link (n=11), Cochrane Library (n=1), and Google Scholar (n=170). After removing duplicates, and shortlisting the total number of articles according to inclusion criteria, the articles included in the present review is 21.

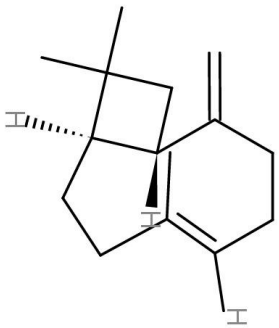
3. Phytochemical constituents of *Munronia pinnata*

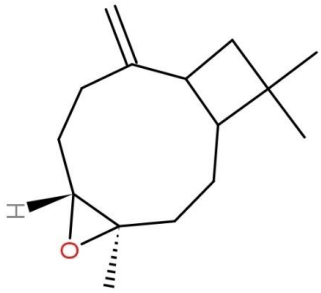
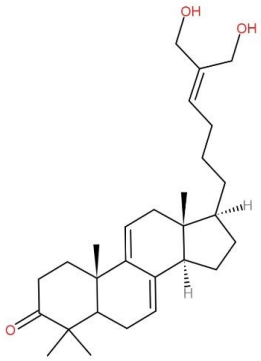
The phytochemical investigation is considered important since it identifies bioactive compounds that can be of therapeutic importance. The literature on *Munronia pinnata*summarises various phytochemical compounds in the plant. Methanolic and Chloroform extracts of *Munronia pinnata*had terpenoids [8]. TLC fingerprints visualized under UV 366 nm exhibited Saponin, Alkaloids, Tannins, Flavonoids, and Steroid Glycosides in leaves, root, and stemextracts [9]. Kaliyadasa *et al.* found that polyphenol content of the *Munronia pinnata* among different leaflets was not significantly different and had a range of amount between 55.35 ± 7.45 mg Gallic acid equivalents (GAE)/g extract and 87.38 ± 5.25 mg GAE/g extract. In contrast, ecotype three leaflet had the highest polyphenol content [10].

A study done in 2014 identified that n-hexane extract of *Munronia pinnata* through GC-MS analysis yielded ubiquitously occurring fatty acids (dodecanoic acid, hexandecanoic acid, 9,12-octadecadienoic acid, octadecanoid acid), sesquiterpenes (beta-caryophyllene, isocaryophellene, caryophyllene oxide), diterpene alcohol (phytol), an acyclic diterpene (neophytadiene), higher alkanes (heptacosane, hentriacontane), a triterpene (squalene), isoprenoid 4,8,12,16-tetramethylheptadecan-4-olide and α-tocopherol. Through the LC-MS analysis several compounds were separated, and comprehensive fragmentation analysis suggested that compound A as ganoderiol F, compound B as triterpenoids, conicasterol C or theonellasterol E, compound C as stigmastentriol, compound D and as stigmasterol [11]. It is important to highlight that beta- caryophyllene, caryophyllene oxide and gandoderiol F are considered active compounds from the isolated pool of phytochemicals(Table1) [12].

The aerial parts of *Munronia pinnata*have limonoids, which are of six different types; munropins A, B, C, D, E, and F, together with three known limonoids, munronins C and F, and munronoid O. Munropins A and B are prieurianin type limonoids, Munropins C, D and E are also limonoids possessing a prieurianin skeleton, Munropin F was assigned as a nimbolinin type limonoid [13].

Table 1: Active biological compounds of *Munronia pinnata* and their properties.

Active Compound	Structure	Therapeutic usage	Reference
Beta-caryophyllene		Act as an anti-inflammatory, antimicrobial, antibacterial and protect against certain neurodegenerative diseases and cancers.	[14, 15]

Caryophyllene oxide		Act as an anti-inflammatory, local anaesthetic, antioxidant, and perhaps helps in cancer treatment.	[14]
Ganoderiol F		Act as an anti-inflammatory, cytotoxic, anti-HIV. It also inhibits the activity of topoisomerases *in vitro*, and it inhibits human immunodeficiency virus-1 protease.	[16]

4. Pharmacological studies of *Munronia pinnata*

4.1 Hypoglycemic activity

*Munronia pinnata*is an excellent plant for hypoglycemic activity. In a study, two types of decoctions were prepared according to conventional (D1) and textual reference (D2). Both conventional and textual decoction exerted significant oral hypoglycemic activity. D1 gave a mean serum glucose level of 4.5mmol/L, which had a 24.8% reduction, and D2 had 5.8mmol/L with 8.2% reduction compared to the control group. This showed that the decoction prepared by the conventional method depicted a higher hypoglycemic activity compared to textual reference decoction [17].

Similarly, the ethanolic extracts of leaf calli showed statistically significant hypoglycemic activity compared to natural plant extracts [18].

A preliminary study conducted by Hapuarachchi in 2011 showed that water and ethanol extracts of *Munronia pinnata*exerted a statistically significant oral hypoglycemic effect in healthy Wistar rats. Adose of 200.0 mg/ kg of ethanol extract showed the highest oral hypoglycemic activity than the other selected doses (50,100 mg/kg). The same dose showed a maximum hypoglycemic effect of 26.7%, but water extract showed a statistically significant impact compared to the control [19].

Further, a study reported that serum glucose concentration was reduced in healthy and diabetic Wistar rats in a dose-dependent manner. To understand the mechanism of hypoglycemic activity, the study showed a significant reduction in intestinal glucose absorption and serum glucose concentration when compared to the control group (distilled water) after glucose challenge. Moreover, it is suggested that *Munronia pinnata*appears to show its oral hypoglycemic activity via several possible mechanisms such as; inhibition of intestinal glucose absorption, possible stimulation of insulin secretion from the beta cells of islets of Langerhans and facilitation of glucose uptake and utilization by peripheral tissues. The study also reported that ethyl acetate extract of *Munronia pinnata* exerted the highest reduction of serum glucose concentration. The TLC yielded two oral hypoglycemic compounds from ethyl acetate extract of *Munronia pinnata*calli and natural plant. Among the tested fractions, the compounds suggested are terpenoids, sesquiterpene and senecrassidiol [20].

Hapuarachchi *et al.* also conducted a study to compare the hypoglycemic effects of water extracts of the natural plant (MPaq) and *Munronia pinnata* callus (MPCaq) in healthy and alloxan-induced diabetic rats. Both MPaq and MPCaq extracts showed a significant decrease in serum glucose levels in normal and diabetic rats. In diabetic animals, MPaq and MPCaq showed a more substantial reduction in SGL (24% and 18%) compared to reference drug; glibenclamide (16%). This study demonstrated that the two *Munronia pinnata* extracts have a statistically significant effect on lowering blood sugar than the reference drug and have proven their scientific basis as a popular folk medicine for diabetes [21, 22].

Kaliyadasa *et al.* showed that *Munronia pinnata* did not exert any alpha-amylase and alpha-glucosidase activity. Thus, it cannot be used to control postprandial hyperglycemia. The study reported that ecotype 3 and 5 extracts mildly inhibited the alpha-amylase enzyme while none of the extracts alpha-glucosidase enzyme activity [10].

4.2 Hepatoprotective activity

The hepatoprotective activity was investigated against CCl_4 induced lipid peroxidation and hepatic injury in healthy Wistar rats by Hapuarachchi in 2014. The results revealed that the toxic effect of CCl_4 exhibits hepatoprotective activity, and it is supported by further histological studies. Hence, it also stated that not only ethanol or water extracts of natural plants but calli of the plant could be used as a treatment plan for certain liver diseases without side effects [23].

4.3 Anti-inflammatory effect

The water and ethanol extracts of *Munronia pinnata* whole plant and callus of it shows anti-inflammatory activity in carrageenan-induced rat paw oedema model compared to control (distilled water) in both diabetic and healthy Wistar rats. Since the anti-inflammatory activity was dose-dependent,

the optimal dose for water extract was 2.0 g/kg and for ethanol extract was 0.5 g/kg. Water extract of both plant and callus significantly inhibited peritoneal phagocytes' infiltration and impaired the production of nitric oxide in peritoneal cells. These results show that anti-inflammatory activity of the plant is mediated through inhibiting the production of Nitric Oxide (NO), infiltration of phagocytes, and antihistamine. The decoction of *Munronia pinnata*has significant anti-inflammatory activity in carrageen-induced paw oedema [20].

Similarly, n-hexane and dichloromethane extract of *Munronia pinnata*can significantly inhibit the 5-LO activity in neutrophils, while methanol and water extracts showed only 15-16% inhibition at 100 µg / ml. n-hexane extract effectively inhibited the 5-LO activity of stimulated human neutrophils with an IC50 of 8.7 µg / ml. Since the n-hexane extract was significant, the mPGES-1 inhibition assay was used to detect the formation of pro-inflammatory PGE_2. The extract inhibited the enzymatic transformation of PGH_2 to PGE_2, catalyzed by mPGES-1 by concentration-dependent. The IC50 for the mPGES-1 inhibition was 1.0 µg / ml. In contrast, no significant radical scavenging activity or inhibition of ROS formation was observed with the n-hexane extract of *Munronia pinnata*. But the water, methanol and DCM extracts reduced the ROS formation, while methanol extract was the most potent with 54.7% of inhibition. The neutrophil viability was not affected in the study investigating the anti-inflammatory activity of *Munronia pinnata* [11].

4.4 Antibacterial activity

Antibacterial effect of traditional concentration decoction of *Munronia pinnata* was investigated against *Escherichia coli* along with *Andrographis paniculata*. The results showed a comparatively lower inhibition of *E. coli* than the *A. paniculate* [24]. But a recent study in 2019, had further modified the extraction of the *Munronia pinnata* by producing silver nanoparticles of the stem and leaf extracts of *Munronia pinnata*. The nanoparticles collected from the *Munronia pinnata* stem and leaf extracts had a particle diameter range of 55.97-76.42 nm and 52.16-64.52 nm respectively. The results showed that the stem and leaf silver nanoparticle extracts exhibited antibacterial activity against *Escherichia coli*, *Staphylococcus aureus* and Bacillus subtitles. The minimum inhibitory concentration (MIC) of stem and leaf silver nanoparticles were 0.375 µg/mL and 0.250 µg/mL for *E. coli*, 0.500 µg/mL and 0.375 µg/mL for *S. aureus* and 0.625 µg/mL and 0.750 µg/mL for Bacillus subtitles respectively [25].

4.5 Antifungal activity

Based on the antifungal screening test by Homans and Fuchs in 1970, TLC was used to study the antifungal activity of methanolic extracts of various ecological species of *Munronia pinnata*. The results revealed mild inhibition of growth of the fungi, *Cladosporium cladosporioides*. Compared to the other three ecotypes (3, 5, 9), the ecotype with 7 leaflets was slightly active against the fungi [10].

4.6 Antioxidant Activity

Munronia pinnata have antioxidant properties that are evident through a few of the studies conducted by the researchers [10, 26, 27]. The study done by Kaliyadasa *et al.* showed that the 3 leaflets of *Munronia pinnata* had the lowest IC50% value. It exhibited the highest scavenging activity with an IC50% of 22.02 ± 3.03 µg/mL. The ecotype with 7 leaflets and 9 leaflets had IC50% of 53.67 ± 16.07 µg/mL and 75.08 ± 8.93 µg/mL respectively, and it showed a relatively lower scavenging activity that was significantly different to 3 leaflets of *Munronia Pinnata*. Similarly, the ecotype of 5 leaflets was significantly different from all other three ecotypes with an IC50% of 179.6 ± 3.68 mg/mL [10].

A more potent free radical inhibition is depicted by a lower IC50%, meaning potent free radical inhibitors are active at low concentrations and 3 leaflet *Munronia pinnata* shows the potent free radical inhibition [10].

Navodani *et al.* concluded that aerial parts of *Munronia pinnata*were observed to be increasing progressively in a dose-dependent manner over the observed concentration through the ferric-ion reducing power assay of LDHs. The strength of ferric ion reducing the power of *Munronia pinnata* was higher than the *Vernonia cinerea* roots and aerial parts in the study. The decoction of *Munronia pinnata* showed an EC50 value of 188.22 ± 24.30 µg/ml [26].

4.7 Antimalarial activity

Aqueous whole plant extract of *Munronia pinnata* with three doses: 800, 1600 and 3200 mg/kg were assessed for *in-vivo* antimalarial activity in terms of schizonticidal activity and chemo suppression. 3200 mg/kg, the highest dose of the whole plant extract showed significant chemo suppression with 75.58%. It was found that the schizonticidal activity and chemo suppression was dose-dependent [28, 29].

4.8 Toxicological Study on *Munronica pinnata*

Safety of *Munronia pinnata* has been reported in many studies. The water and ethanol extracts of *Munronia pinnata* did not produce any mortality or changes in behavioral activity in healthy Wistar rats. The haematological (haemoglobin) and biochemical tests (serum alanine aminotransferase (ALT), aspartate aminotransferase (AST), γ-glutamyltransferase (GGT), alkaline phosphatase (ALP), creatinine) were within the reference ranges for both test and control groups, revealing that the *Munronia pinnata* Cali and natural plant do not exert any side effects [30].

A study was conducted by Darmadasa *et al.* to describe the cytotoxic potential of five morphotypes of *Munronia pinnata* using brine shrimp toxicity assay. The leaf, stem and root extracts of all the ecotypes of *Munronia pinnata* showed cytotoxicity. The different morphotypes of plants were assigned with morphotypes codes with four letters by indicating collected district in Sri Lanka, name of the exact location of collection and the number of leaflets in each morphotype: For APRG5 (Anuradhapura district, Ritigala area bearing five leaflets), BDHM3 (Badulla district, Haldummulla area bearing three leaflets), GPWP3 (Gampaha district, Warakapola area bearing three leaflets), MGMD3 (Moneragala district, Madulla area with three leaflets) and MGNG3 (Moneragala district, Nilgala area with three leaflets). Thus, these different plants from different locations were tested. All parts of five morphotypes of *Munronia pinnata* showed potent cytotoxic activity. The order of potency was roots>stems>leaves. The highest cytotoxicity exhibited by morphotype collected from Nilgala forest reserve. The study also concluded that none of the mice administered with aqueous extracts of *Munronia pinnata* died. Moreover, there were no signs of overt toxicity, stress and aversive behaviours in both treated and control groups of mice [28]. Meanwhile, various compounds identified from the *Munronia pinnata* exhibited cytotoxicity activities [12] and Hapuarachchi *et al.* also reported that the acute toxicity and behavioural studies showed no signs of toxicity in rats [18].

4.9 Antivenom studies on *Munronia pinnata*

Snakebite, one of the "Neglected Tropic Diseases" is potentially a life-threatening disease that injects a mixture of toxins (venoms) into the body by a snake bite. According to WHO, about 5 million snake bites occur each year, resulting in up to 2.7 million envenomings. Snakebite is either fatal or causes permanent disabilities and amputations with a record of 400,000 worldwide [31].

Snake antivenoms are an effective method of treatment. There are several herbal plants used to treat snake venoms, and *Munronia pinnata* is one such plant that had been used since decades ago. Dharmadasa *et al.* reported that *Munronia pinnata* had been recorded to use for the treatment of snake bites in Sabaragamuwa and Western provinces in Sri Lanka. It has been used to treat snake bites from Cobra (*Naja Naja*), Russell's viper (*Daboia russelii*), Krait (*Bungarus ceylonicus*), Hump Nosed Viper (*Hypnale hypnale*) and scant venomous snake [32]. The plant is used as both internal (peyawa-drinking) and external (paththu-bandaging) treatments for the snakebite [32, 33].

5. Discussion

Of the 422,000 plant species documented, only 12.5% have been used as medicines from ancient times, not necessarily for its medicinal value. Furthermore, research has been taken a peak to identify the medicinal properties of plants, thus proving its use by our ancestors. The available *in-vitro* and *in-vivo* evidence suggests that *Munronia pinnata* has hypoglycemic, antimalarial, antibacterial, antifungal, cytotoxic, antioxidant, anti-inflammatory and hepatoprotective properties. In addition, the toxicological studies showed no side effects, biochemical changes and behavioural changes in animal models used in the *in-vitro* studies.

The entire plant itself is used for the treatment based on traditional formularies while different parts of the plant (stem, leaf, root) has been used in extract preparation. The *in-vivo* and *in-vitro* studies done for different parts also showed potent activity. The mechanism of the hypoglycemic effect is well studied with the *in-vivo* models than the *in-vitro*. But the exact mechanism of the property is still undiscovered among the researches done so far. Based on the investigation done in the diabetes type 2 rats, it is suggested that *Munronia pinnata* appears to exert its oral hypoglycemic activity through several possible mechanisms. These may include inhibiting intestinal glucose absorption, possible stimulation of insulin secretion from the beta cells of islets of Langerhans and facilitation of glucose uptake, and utilization by peripheral tissues [20]. The two extracts' oral hypoglycemic activity is comparable with the time course of synthetic standard antidiabetic agents. Hypoglycemic medicines have to be administered for a more extended period; the chances of reducing the side effects are crucial therapeutic management. Being said that, toxicity studies have revealed that both the ethanol or water extract of the plant did not cause any biochemical changes or adverse effects. This research evidence elaborates the safety of the plant [20, 30].

There were no documented studies on the anticancer properties of *Munronia pinnata*. However, the phytochemicals found in the plant have exhibited different properties in various studies. One such property is anticancer activity. The phytochemical profile elaborated the isolation of ganoderiol F which has shown excellent inhibition against mouse Lewis Lung cancer (LLC), breast cancer (T47D) and mouse sarcoma cell lines (S-180 and Meth-A)[34]. The potential mechanism of anticancer effect on breast cancer was described as inhibition of the cell cycle progression and arresting the dividing cells in the G1 phase, hence acting as the CDK4/CDK6 inhibitors in breast cancer. Furthermore, beta-caryophyllene has shown anticancer effect by inhibiting the colon cancer cell lines (HCT-116 and HT-29), gastric cancer (SNU-1, SNU-16) and cervical cancer lines (Hela). This compound possibly exerts its action by inhibiting the proliferation and survival rate of the tumour cells [35].

Further studies had found that the highest phenolic content was observed in *Munronia pinnata*, which could be a reason for the plant's anti-inflammatory activity [10]. Since the most common phytochemicals also manifested their properties as anticancer, anti-inflammatory and paved a pathway that these compounds could be isolated to find a lead molecule[12]. It is also important to highlight that the limonoids are found in *Munronia pinnata* which could have the properties of the limonoids isolated from the same genre of the plant, such as; antiproliferative [36], antiviral and antifungal, antibacterial, anticancer activities [37].

The presence of similar phytochemicals in the *Munronia pinnata* and other plants indirectly validates the use of the alternative plants for its medicinal properties due to the extinct and higher cost of *Munronia pinnata*. For instance, the phytochemicals saponin, alkaloids, tannins, flavonoids, steroid glycosides are found in both *Munronia pinnata*and *A. paniculata*. Therefore, it validates the use of A. paniculata as a substitute since the ancient traditional era in Sri Lanka [9]. While, *A. paniculata* is widely used as a fever-reducing herbal medicine, particularly in the current scenario of COVID -19 [38] pandemic. However, *Munronia pinnata*is used as a substitute of *Swertia Chirata*, which is not available in Sri Lanka [22]. The presence of antiviral properties of similar plants to *Munronia pinnata* suggests that this plant also has antiviral activity.

The antifungal property of the *Munronia pinnata* shows that the plant is effective against *Cladosporium cladosporioides* [10], but the rest of the fungal species have not been studied. Since it has significant activity against the fungal species, the plant may possess antifungal and antibacterial properties against a broad range of micro-organisms which is yet to be discovered.

There are several limitations to draw a balanced conclusion of the study. The *Munronia pinnata* has not been researched much, which led to a lack of studies to prove the essence of the plant. The other drawback was the authentication or the validation of the plant was not mentioned in studies. Since the plant has different morphological characteristics and growth patterns, the studies didn't address all these in one research. The lack of human trials has compromised the knowledge regarding the tolerability and effectiveness of administering the plant preparation from *Munronia pinnata*.

6. Conclusion

Munronia pinnata has been extensively used among the native traditional people in Sri Lanka, India, China. The review found that different parts of the plant possess various phytochemicals and used as a hypoglycemic, Hepatoprotective, Anti-inflammatory, Antifungal, Antibacterial, Anti-oxidant, Anticancer, antivenom due to its safety which is evident from toxicological Study on *Munronica pinnata*. Through this robust evidence of the *Munronia pinnata*, it was found that there is a scarcity in the research on the mechanism of action of the phytochemicals found in the plant, anticancer studies, and antimicrobial

investigations for a broad spectrum of bacteria. Thus, the necessity for the future studies to fully understand the phytochemical profile and the pharmacological basis of *Munronia pinnata* to administer the medicine within a safe window and ensure its application in modern medicine through lead molecules.

7. Abbreviations

LC-MS: Liquid chromatography-mass spectrometry; TLC: Thin-layer chromatography; U.V.: ultraviolet; SGL: serum glucose levels; 5-LO: 5-Lipoxygenase; mPGES-1: Microsomal prostaglandin E synthase-1; PGH2: Prostaglandin $H_{2;}$ PGE2: Prostaglandin $E_{2;}$ ROS: reactive oxygen species; IC50: Half-maximal inhibitory concentration; WHO: World health organization; CDK4/CDK6: Cyclin-dependent kinase 4 and Cyclin-dependent kinase 6.

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Not applicable

9. Competing interests

The authors declare that they have no competing interests.

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