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Review

Antiviral medicinal plants found in Lanna traditional medicine

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ABSTRACT

Traditional medicine uses a multitude of plants to create medicinal formulations, some of which show antiviral properties that may be of benefit in treating emerging viral diseases, including Covid-19. Lanna, an ancient Kingdom in Northern Thailand, with a thriving culture that continues to this day and has a rich history of traditional medicine using local plants that is still practiced today. To find potential antiviral medicinal candidates, we examined ancient manuscripts, interviewed traditional healers practicing today, and inventoried current traditional medicines to catalogue 1400 medicinal formulations used in Lanna traditional medicine. We then narrowed this list to find those traditionally used to treat diseases that in their original use and descriptions most likely map to those we know today to be viral diseases. We identified the plants used in these formulations to create a list of 64 potential antiviral herbal candidates drawn from this ancient Lanna wisdom and matched these to the scientific literature to see which of these plants had already been shown to possess antiviral properties, generating a list of 64 potential antiviral medicinal candidates from Lanna traditional medicine worth further investigation for treating emerging viral diseases.

Contents

1. Introduction

Thai traditional medicines and pharmacopoeia are documented in traditional reference works and textbooks. Ethnomedicine or indigenous medicine continues to play an important role and is still being practiced throughout Thailand, including in the private sector and through local healers and monks. The knowledge and skills of traditional healers was not usually recorded or written but transferred from generation to generation, father to son and teacher to students. The healers and herbalists were usual the same people. The medicaments were usually compound medicines, characterized as having hot, cold, or equally hot and cold properties. The taste sensations of each herb are similar to the activities associated with the medicinal formulation. Hot property medicines

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Fig. 1. A map of Thailand showing Lanna Kingdom shaded.

are derived from herbs that produce heat in the body, such as fresh ginger (*Zingiber officinale* Roscoe). Ginger has a sweet-hot property and releases the air element. Consuming ginger warms the body and can relieve fever-related insomnia and flatulence. Cold property medicines, such as *Ficus racemosa* L, can reduce the heat in the body and relieve fever and flu. Some herbs, such as *Leucaena leucocephala* (Lam.) de Wit, contain equal parts of hot and cold properties; Medicines derived from these are used to stabilize and normalize the body temperature. The Royal Thai Government's Department of Thai Traditional and Alternative Medicine, Ministry of Public Health restores and conserves traditional Thai medicine and knowledge, conducts pharmaceutical research of the traditional herbs, and promotes their use.

Lanna was an ancient kingdom in Northern Thailand, covering eight provinces–Chiang Mai, Chiang Rai, Phayao, Phrae, Nan, Lamphun, Lampang, and Mae Hong Son (Fig. 1). Chiang Mai was the center of the Lanna Kingdom. While the kingdom is gone, much of its culture remains in the people of the region. They retained a close relationship to nature and many of their traditional beliefs, which together provided continued support for traditional healers and the application of medicinal plants as used for centuries in treating those in the Lanna community.

Traditionally, two types of medicines, YaKae and YaTheep, are combined to treat these diseases. YaKae medicines help cure the patient while YaTheep medicines drive off the toxin or lessen the course of illness. If patients are treated with only YaTheep or YaKae medicine, it will take longer to recover, and the disease will recur sooner. The most common YaKae and YaTheep medicines that we found were referenced as Ya Kae Ha Ton and Ya Sri Munluang (Table 1).

In the Lanna context, antiviral medicines typically use names associated with the wind and hot elements. The wind element is involved with the respiratory system. Several symptoms were mentioned, including Khikoo (asthma) and Khaang khare (severe asthma). The hot element is involved with fever, such as fever with toxic substances, which refers to fever accompanied by inflammation. Fever with cough means the prolonged fever effect to the lung. Other fevers are E-suk-e-sai (chicken pox), Ngu-sawad (herpes zoster), Phee kuer (skin rash scattered with pustules) and Hadd (measles rash). The traditional preparations were first documented on palm leaves (Fig. 2) and mulberry bark (Fig. 3).

This paper aimed to gather the formulations of antiviral medicaments used in traditional healing from a variety of sources in the Lanna region of Northern Thailand: palm leaf manuscripts, mulberry bark manuscripts, translations, researches, documents written by healers, interviews with folk healers, and an inventory of herbal plants and medicines in the region. In this study, we

Table 1
Medicinal plants of YaKae and YaTheep formula.

Formula	Scientific names	Pharmaceutical parts
YaKae Ya Kae Ha Ton	*Nyctocalos brunfelsiiflora* Teijsm. & Binn.	Roots
	Melothria affinis King	Roots or stems or leaves or aerial parts of a plant
	Inula cappa (Buch.-Ham. ex D.Don) DC.	Stems or roots
	Tinospora crispa (L.) Hook. f. & Thomson	Stems
	Tacca chantrieri André	Roots
Yatheep Ya Sri Munluang	*Momordica charantia* L.	Fruits
	Cyperus rotundus L.	Rhizome
	Tinospora crispa (L.) Hook. f. & Thomson	Stems
	Vitex trifolia L.	Fruits
	Piper nigrum L.	Fruits
	Micromelum minutum Wight & Arn.	Stems
	Eclipta prostrata (L.) L.	Aerial parts of a plant
	Strychnos viridiflora A.W. Hill.	Whole plants (except fruits)
	Inula cappa (Buch.-Ham. ex D.Don) DC.	Roots or leaves
	Afzelia xylocarpa (Kurz) Craib.	Stems or roots

Fig. 2. A palm leaf manuscript (The document kept in Herbal Museum, Medicinal Plant Innovation Center, Faculty of Pharmacy, Chiang Mai University).

Fig. 3. A mulberry bark manuscript (The document kept in Herbal Museum, Medicinal Plant Innovation Center, Faculty of Pharmacy, Chiang Mai University).

intensively searched the Thai traditional medicine references for traditional herbs and medicaments that might offer promise for treating viral diseases or their symptoms. From these preliminary studies, we found that traditional medicinal plants can treat viral diseases and may be of benefit in treating emerging infectious diseases, including Covid-19.

2. Antiviral medicinal plants in Lanna

We analyzed palm leaf and mulberry bark manuscripts from the eight-province Lanna region of Northern Thailand to find traditional medicinal formulas that might offer antiviral properties. We found and analyzed 1400 formulas, mapping their traditional uses to infections that are known today to be viral, such as influenza, several symptoms of toxic fever with or without cough, fever with asthma, chicken pox, herpes zoster, skin rashes with abscesses or pustules, and measles.

About 1400 formulas were selected and their constituent herbs were cross-referenced with current antiviral research to identify

Table 2
Antiviral medicinal plants found in Lanna traditional medicine.

Family names	Thai names	Scientific names	Pharmacological effects	References
Acanthaceae	Pha Ya Yo	*Clinacanthus nutans* (Burm.f.) Lindau	Anti-Cyprinid herpesvirus 3 (LC_{50} of ethanolic extract was > 5 mg/mL, ED_{50} were 0.99, 0.78, 0.75 and 0.71 mg/mL at 1, 2, 3 and 4 h pre-infection) Anti-HSV type 1 activity (Subtoxic concentration of compounds **1**, **2** and **3**, IC_{50} were 1.96, 3.11 and 3.11 nmol/L) Anti HSV type 2 activity (Methanolic extract showed a low insignificant effect) Anti-Dengue virus (DENV-2, strain 16681) (Ethanolic extract showed moderate activity, IC_{50} was 31.04 μg /mL)	Haetrakul et al., 2017; Sakdarat et al., 2009; Yoosook et al., 1999; Tu et al., 2014
Acanthaceae	Sang Ko Ra Ni Dong	*Lepidagathis fasciculata* (Retz.) Nees	–	–
Acoraceae	Wan Nam	*Acorus calamus* L.	Anti-Dengue virus serotype 2 (DENV-2) NGC strain (Inhibition of methanolic extract was to 96.5%) Anti-HIV-1 reverse transcriptase activities (IC_{50} of hexane extract was 32.96 μg/mL)	Rosmalena et al., 2019; Silprasit et al., 2011
Amaranthaceae	Ngon Kai	*Celosia argentea* L.	–	–
Amaranthaceae	Thai	*Celosia cristata* (synonym)	Antiviral deoxyribonuclease and ribonuclease activity (CCP-27 showed DNase and RNase activity)	Begam et al., 2006
Anacardiaceae	Ma Kok	*Spondias pinnata* (L. f.) Kurz	–	–
Apiaceae	Bua Bok	*Centella asiatica* (L.) Urb.	Anti-Herpes simplex type-1 (HSV-1) and vesicular stomatitis (VSV) viruses (MIC of ethanolic extract against VSV was 0.1 mg/mL) Anti-Herpes simplex virus types 1 (HSV-l; KOS strain) and 2 (HSV-2; Baylor 186 strain) (ED_{50} were 362.40 and 298.84 μg/mL)	Ali et al., 1996; Yoosook et al., 2000
Apocynaceae	Sat Ta Ban	*Alstonia scholaris* (L.) R. Br.	Anti-Dengue type 2 (DENV2) and respiratory syncytial virus type A (RSV A) (The early phase of infections was inhibited by alstotides) Anti-Coxsackie B2, Polio virus, Herpes Simplex virus, and Hepatitis B virus (Water and alcohol extracts showed antiviral activity)	Nguyen et al., 2015; Antony et al., 2014
Apocynaceae	Klet Nak Ka Rat	*Dischidia imbricata* (Blume) Steud.	–	–
Apocynaceae	Cha Em	*Myriopteron extensum* (Wight & Arn.) K. Schum.	–	–
Apocynaceae	Khruea Khao	*Parameria laevigata* (Juss.) Moldenke	–	–
Apocynaceae	Muak Khao	*Parameria barbata* (Blume) K.Schum. (synonym)	–	–
Apocynaceae	Kha Yom Yai	*Rauvolfia verticillata* (Lour.) Baill.	–	–
Araceae	Phak Nam	*Lasia spinosa* (L.)	–	–

Table 2 (*continued*)

Family names	Thai names	Scientific names	Pharmacological effects	References
		Thwaites		
Arecaceae	Mak	*Areca catechu* L.	Anti-Human immunodeficiency virus (HIV-1) integrase activity (IC_{50} of ethanolic and water extracts were 3.2 and 15.7 μg/mL)	Bunluepuech & Tewtrakul, 2011
Asparagaceae	Chan Daeng	*Dracaena cochinchinensis* (Lour.) S.C.Chen	–	–
Asparagaceae		*Dracaena loureiroi* Gagnep. (synonym)	–	–
Bignoniaceae	Pip	*Millingtonia hortensis* L.f.	Anti-Human immunodeficiency virus (HIV-1) integrase activity (IC_{50} of ethanolic extract was 77.7 μg/mL) Anti-Herpes simplex virus type 1 (IC_{50} of methanolic extract was 285 μg/mL)	Suedee et al., 2014; Akanitapichat et al., 2005
Burseraceae	Ma Kok Kluean	*Canarium subulatum* Guillaumin	Anti-Herpes simplex type-1 (HSV-1) (IC_{50} of β-amyrin and cubebin were 234 and 280 μmol/L)	Sritularak et al., 2013
Burseraceae	Ta Khram	*Garuga pinnata* Roxb.	–	–
Celastraceae	Ma Duk	*Siphonodon celastrineus* Griff.	–	–
Commelinaceae	Kam Pu Lut	*Tradescantia zebrina* var. zebrina	–	–
Commelinaceae		*Zebrina pendula* Schnizl. (synonym)	–	–
Compositae	Kot Chu La Lam Pha	*Artemisia vulgaris* Mattf.	Anti-Herpes simplex virus type 1 (HSV1) (Protection rates was 63.94%)	Karamoddinia, Emami, Ghannad, Sani, & Sahebkar, 2011
Compositae	Nat Yai	*Blumea balsamifera* (L.) DC.	Anti- Human immunodeficiency virus (HIV-1) integrase activity (IC_{50} of ethanolic and water extracts were > 100 and 7.8 μg/mL) Anti-Zika virus (ZIKV) (EC_{50} of aqueous extract was 1.6972 mg/mL) Immunomodulatory product registered as traditional medicines in Indonesia.	Bunluepuech & Tewtrakul, 2011; Vista et al., 2020; Hartanti et al., 2020
Convolvulaceae	Bai Ra Bat	*Argyreia nervosa* (Burm. f.) Bojer	Anti-HIV activity (Ethanolic extract showed anti-HIV activity of syncytium reduction assay > 80% and EC_{50} was 11.87 μg/mL) Anti-HIV type 1 reverse transcriptase (Inhibition ratio of water extract was 84%)	Sareedenchai et al., 2014; Woradulayapinij et al., 2005
Costaceae	Ueang Mai Na	*Cheilocostus speciosus* (J.Koenig) C.D.Specht	–	–
Orchidaceae		*Habenaria linguella* Lindl.	–	–
Cucurbitaceae	Fak	*Benincasa hispida* (Thunb.) Cogn.	–	–
Cucurbitaceae	Phak Tam Lueng	*Coccinia grandis* (L.) Voigt	–	–
Cyperaceae	Ya Haeo Mu	*Cyperus rotundus* L.	Anti-Hepatitis A, Herpes simplex type 1, and Coxsackie viruses (Antiviral activities of oil were 7.98, 14.21 and 8.79%) Anti-hepatitis B virus (HBV) (IC_{50} of ethyl acetate, n-butanol and aqueous fractions were 46.2, 94.8, and 107.8 μg/mL) Anti-Herpes simplex-1 virus (HSV), poliomyelitis-1 virus (POLIO) and vesicular stomatitis virus (VSV) (Hydro-alcoholic extract showed virucidal effect against HSV)	Samra et al., 2020; Parvez et al., 2019; Soltan & Zaki, 2009
Euphorbiaceae	Di Mi	*Claoxylon parviflorum* A.Juss.	–	–
Euphorbiaceae		*Acalypha spiciflora* Burm.f. (synonym)	–	–
Euphorbiaceae	Phang Khi	*Croton crassifolius* Geiseler	–	–
Euphorbiaceae	Som Chao Yai	*Euphorbia tortilis* Rottler ex Ainslie	–	–
Euphorbiaceae	Kham Saet	*Mallotus philippensis* (Lam.) Müll.Arg.	Anti Sindbis (SINV), human polio virus 1 (POLIO), and Herpes simplex virus 1 (HSV) (MIC of methanolic extracts were 200, 50, and 25 μg /mL)	Taylor et al., 1996
Fabaceae	Nam Khi Raet	*Acacia pennata* (L.) Willd.	–	–
Fabaceae	Kra Dai Ling	*Bauhinia scandens L.*	–	–
Fabaceae	Fang	*Caesalpinia sappan* L.	Anti-Influenza viral activity (Influenza viruses A/PR/8/34 (H1N1), B/Jiangsu/10/2003, and Influenza virus A/Guangdong/243/72 (H3N2) (IC_{50} of 3-deoxysappanchalcone and sappanchalcone against influenza virus (H3N2) were 1.06 and 2.06 μg/mL) Anti-Porcine reproductive and respiratory syndrome virus (PRRSV) (Anti-PRRSV agents were coumarin, byakangelicin, and flavonoids)	Liu et al., 2009; Arjin et al., 2021

(*continued on next page*)

Table 2 (*continued*)

Family names	Thai names	Scientific names	Pharmacological effects	References
Fabaceae	Thua Rae	*Cajanus cajan* (L.) Millsp.	Anti-Herpes simplex virus type 1 (HSV-1) and type 2 (HSV-2) (IC_{50} of ethanol extract against HSV-1 and HSV-2 were 0.022 and 0.1 μg/mL) Anti-Measles virus (MV) (Hot-water and ethanol extracts showed anti-MV properties)	Zu et al., 2010; Nwodo et al., 2011
Fabaceae	Thua Phra	*Canavalia ensiformis* (L.) DC.	–	–
Fabaceae	Cha Em Thet	*Glycyrrhiza glabra* L.	Anti-Newcastle disease virus (60 mg/100 mL of water extract inhibited replication of Newcastle disease virus) Anti-Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Glycyrrhizin inhibited SARS-CoV-2 replication at 0.5 and 1 mg/mL) Anti-Human immunodeficiency virus (HIV) and Herpes simplex virus (HSV) (EC_{50} of alkaline (pH12.0) extract against HIV-infected cells was 54.1 μg/mL and EC_{50} of isoliquiritin against HSV-infected were 0.84 and 0.14 μg/mL) Anti-Japanese encephalitis virus strains (JEV), West Nile virus strains, Sindbis, Adenoviruses, and Coxsackie viruses (The ammonium salt of GA inhibited plaque formation of JEV at 1000 ug/mL) Anti-influenza A/H1N1/pdm09 virus (Selectivity index of glycyrrhizic acid conjugates with aromatic amino acids methyl esters (phenylalanine and tyrosine) and s-benzyl-cysteine were 61, 38, and 71)	Omer et al., 2014; Sand et al., 2021; Fukuchi et al., 2016; Badam, 1997; Baltina et al., 2015
Fabaceae	Thua Paep	*Lablab purpureus* (L.) Sweet	–	–
Fabaceae		*Dolichos lablab* L. (synonym)	Anti-Severe acute respiratory syndromecoronavirus (SARS-CoV-2), in silico (19-Nortestosterone, mesterolone, oleanolic acid, rutin, and ursolic acid showed a low binding energy in MPro, HR1, and NF-κB)	Purwanti et al., 2021
Fabaceae	Thua Phu	*Psophocarpus tetragonolobus* (L.) DC.	–	–
Lecythidaceae	Kra Don	*Careya arborea* Roxb.	–	–
Lecythidaceae		*Careya sphaerica* Roxb. (synonym)	Anti-Herpes simplex virus type 1 (IC_{50} of dichloromethane–methanol and methanolic extracts were 24, and 30 μg/mL)	Akanitapichat et al., 2005
Marsileaceae	Phak Waen	*Marsilea crenata* C. Presl	–	–
Menispermaceae	Thao Ya Nang	*Tiliacora triandra* Diels	–	–
Moraceae	Sa Lae	*Broussonetia kurzii* (Hook.f.) Corner	–	–
Moraceae	Ma Duea Plong	*Ficus hispida* L.f.	–	–
Orchidaceae	Phaen Din Yen	*Nervilia concolor* (Blume) Schltr.	–	–
Orchidaceae		*Nervilia aragoana* Gaudich. (synonym)	–	–
Pandanaceae	Lam Chiak	*Pandanus utilis* Bory	–	–
Pandanaceae		*Pandanus odoratissimus* Jacq. (synonym)	–	–
Passifloraceae	Phak Sap	*Adenia viridiflora* Craib	–	–
Phyllanthaceae	Kang Pla Daeng	*Flueggea leucopyrus* Willd.	–	–
Phyllanthaceae		*Securinega leucopyrus* (Willd.) Müll.Arg.	–	–
Phyllanthaceae	Kang Pla Khruea	*Phyllanthus reticulatus* Poir.	–	–
Phyllanthaceae	Phak Wan Ban	*Sauropus androgynus* (L.) Merr.	–	–
Piperaceae	Di Pli	*Piper retrofractum* Vahl	Anti-Mosquito-borne dengue virus (DENV) (Virucidal activity of ethanol extract against DENV2 was 84.93%)	Klawikkan et al., 2011
Piperaceae		*Piper chaba* Hunter (synonym)	–	–
Primulaceae	Cham	*Ardisia attenuata* Wall. ex A.DC.	–	–

Table 2 (*continued*)

Family names	Thai names	Scientific names	Pharmacological effects	References
Primulaceae	Kam Lang	*Ardisia villosa* Roxb.	–	–
Primulaceae	Chang Phueak	*Ardisia vestita* Wall. (synonym)	–	–
Proteaceae	Mueat Khon Tua Phu	*Helicia nilagirica* Bedd.	–	–
Rhamnaceae	Rang Daeng	*Ventilago denticulata* Willd.	Anti-Herpes simplex virus type 1 (HSV-1), Poliovirus type 1, and Measles virus (EC_{50} of ethanol extract against HSV-1 was 46.3 μg/mL)	Lipipun et al., 2003
Rubiaceae	Kra Bian	*Ceriscoides turgida* (Roxb.) Tirveng.	–	–
Rubiaceae		*Gardenia turgida* Roxb.	–	–
Rubiaceae	Chan Tha Na	*Tarenna hoaensis* Pit.	–	–
Rutaceae	Kaeo	*Murraya paniculata* (L.) Jack	Anti-A/duck/ Egypt/ Q5569D/2012(H5N1) virus (IC_{50} of extract was 0.15 μg/mL)	Baker, Ibrahim, Kandeil, & Baz, 2017
Salvadoraceae	Nam Phung Do	*Azima sarmentosa* (Blume) Benth. & Hook.f.	–	–
Solanaceae	Dap Yang	*Solanum erianthum* D. Don	Anti-Hepatitis B virus (HBV) (IC_{50} of solamargine was 1.57 mmol/L)	Chou et al., 2012
Solanaceae	Tong Tang	*Solanum spirale* Roxb.	–	–
Stemonaceae	Non Tai Yak	*Stemona tuberosa* Lour.	Anti-Herpes simplex viruses HSV type 1 and type 2 (TI value of ethanolic extract against HSV-1 was 41.30 and TI value of aqueous extract against HSV-2 was 3.64)	Chaliewchalad et al., 2013
Vitaceae	Khueang	*Leea rubra* Blume ex Spreng.	–	–
Zingiberaceae	Kra Wan Thet	*Elettaria cardamomum* (L.) Maton	–	–
Zingiberaceae	Khing	*Zingiber officinale* Roscoe	Activity and expression of Matrix metalloproteinase (MMP-2, MMP-9), and Tissue inhibitor of metalloproteinases (TIMP-1, TIMP-2) (Aqueous extract inhibited the activities and expression of MMP-2 and MMP-9) Anti-Human respiratory syncytial virus (HRSV) (Fresh ginger inhibited HRSV-induced plaque formation in HEp-2 and A549) Anti-Chikungunya Virus (CHIKV) (IC_{50} of [6]-gingerol showed post and full treatment with 0.038 mmol/L and 0.031 mmol/L) Anti-Chikungunya Virus (CHIKV) (At maximum non-toxic dose and half maximum non-toxic dose, Vero cells viability increased 51.05% and 35.1%)	Sharma et al., 2015; Chang et al., 2013; Hayati et al., 2021; Kaushik et al., 2020

those for which findings have reported antiviral activity. Sixty-four medicinal plants in Thai names with a scientific name were selected and reviewed for their antiviral properties. Synonym names were included for analysis. The medicinal plants we found belonged to the following families (number per family): Acanthaceae (2), Acoraceae (1), Amaranthaceae (2), Anacardiaceae (1), Apiaceae (1), Apocynaceae (6), Araceae (1), Arecaceae (1), Asparagaceae (2), Bignoniaceae (1), Burseraceae (2), Celastraceae (1), Commelinaceae (2), Compositae (2), Convolvulaceae (1), Costaceae (1), Cucurbitaceae (2), Cyperaceae (1), Euphorbiaceae (5), Fabaceae (9), Lecythidaceae (2), Marsileaceae (1), Menispermaceae (1), Moraceae (2), Orchidaceae (3), Pandanaceae (2), Passifloraceae (1), Phyllanthaceae (4), Piperaceae (2), Primulaceae (3), Proteaceae (1), Rhamnaceae (1), Rubiaceae (3), Rutaceae (1), Salvadoraceae (1), Solanaceae (2), Stemonaceae (1), Vitaceae (1), and Zingiberaceae (2).

Previous studies have shown that 24 Lanna medicinal plants had antiviral activities (Table 2). Medicinal plants that have potential antiviral activities include *Clinacanthus nutans* (Burm.f.) Lindau, *Blumea balsamifera* (L.) DC., *Caesalpinia sappan* L., and *Glycyrrhiza glabra* L.

C. nutans, Pha Ya Yo, belongs to the family Acanthaceae. In Thailand, this plant has been used to treat skin ailments. Leaves of *C. natans* are extracted with ethanol and used to prepare topical formulations to treat Herpes simplex virus and Varicella-zoster virus. The plant has been tested for several anti-viral properties, including anti-Cyprinid herpesvirus 3, anti-HSV type 1 activity, anti-HSV type 2 activity, and anti-Dengue virus (Haetrakul et al., 2017; Sakdarat et al., 2009; Yoosook et al., 1999; Tu et al., 2014). Chlorophyll derivatives (phaeophytins) were extracted from leaves of *C. natans* and showed anti-Herpes simplex virus type 1 (HSV-1) activities at subtoxic concentrations. These compounds could prevent the entry of the virus into cells (Sakdarat et al., 2009).

B. balsamifera, Compositae, Nat Yai, has been used widely in Thai traditional medicine, including as a carminative, for relieving sinusitis pain, and preparing bath water for mothers after giving birth. The main compounds have been identified, and include essential oil, steroids, flavonoids, and coumarin (Ruangrungsi et al., 1985). Many anti-viral properties have been tested, including anti-HIV-1 integrase activity and anti-Zika virus (ZIKV). Antibacterial and antifungal activities against *Bacillus cereus*, *Staphylococcus*

aureus, *Candida albicans*, and *Enterobacter cloacae* have been reported (Sakee et al., 2011).

The chemical compounds have been extracted from *Caesalpinia sappan* L., including brazilein, brazilin, protosappanin A, 3-deoxysappanchalcone, sappanchalcone, and rhamnetin. These compounds showed activities against neuraminidase (NA) inhibitory activity (anti-Influenza viral activities) (Liu et al., 2009). *C. sappan*, Fabaceae, is distributed throughout Southeast Asia, Africa, and America. Its size was small to medium. The heartwood of *C. sappan* has been used to treat inflammatory disease, arthritis, and cancer. Other biological activities of this plant have also been investigated, including antioxidant activities and its protective effects against DNA damage (Saenjum et al., 2010).

Licorice, *Glycyrrhiza glabra* L., has been used as a traditional medicine, particularly as an expectorant to treat sore throats and coughs. The licorice plant has a sweet taste due to glycyrrhizin and its derivatives. It has been tested for its anti-viral properties against several viruses, including Newcastle disease virus, SARS-CoV-2, human immunodeficiency virus (HIV), Herpes simplex virus (HSV), Japanese encephalitis virus (JEV), West Nile virus, Sindbis, adenoviruses, Coxsackie viruses, and Influenza A/H1N1/pdm09 virus. Moreover, licorice extract has been shown to inhibit *Candida albicans*, *Lactobacillus casei*, and *Lactobacillus acidophilus* (Sirilun et al., 2018).

3. Conclusion

We analyzed over one thousand traditional formulations made from various medicinal plants to find those that might offer antiviral properties. Previous scientific research supported the antiviral properties of many of these formulations. As some of the documents studied were over 100 years old, we were unable to identify some of the plants referenced, as old names could not always be matched to their scientific names. Only a few of the plants we identified based on their traditional uses as possibly offering antiviral properties have been investigated both *in vitro* and *in vivo*. Further studies are needed to identify their active components and mechanisms of action.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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