

Geographic Information Database of Herbs against COVID-19 in Thailand: The Medicinal Plants those Folk Healers Commonly Used for Treatment and Boosting People's Immunity

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Abstract

*The rapid outbreak of coronavirus disease 2019 (COVID-19) has demonstrated the need for the development of new vaccine candidates and therapeutic drugs to fight against the underlying virus, severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). Currently, no antiviral treatment is available to treat COVID-19, as treatment is mostly directed at relieving the symptoms, and retrospectively, herbal medicinal plants have been used for thousands of years as a medicinal alternative, including for the treatment of various viral illnesses. The aim of this study is to conduct a survey in terms of identifying the area where the population commonly uses the medicinal plant in comparison to the cumulative number of COVID-19 reports in each area, including the classification of medicinal plants by type and a stepwise approach shown in the form of geographic information maps in those areas. An observational study on the cultivation of medicinal plants those folk healers commonly used for healing, beneficial for treatment and strengthening the immunity of the people in 9 provinces of Thailand. According to the situation of the spread of COVID-19, there are people infected in Thailand. In each area where medicinal plants were used, there was a significant positive result when compared to the cumulative COVID-19 incidence; the majority was with the lowest cumulative COVID-19 incidence and the most commonly used medicinal plants, such as *Artemisia annua*, *Harrisonia perforate* (Blanco) Merr, *Capparis micracantha*, *Tacca leontopetaloides*, *Andrographis paniculata*, *Phyllanthus emblica*, *Ficus carica*, *Tiliacora triandra*, *Terminalia bilaria*, and *Cannabis indica*. This study exercise may lend enough credence to the potential value of Thai medicinal plants (herbs) as possible leads in anti-COVID-19 drug discovery through research and development.*

Keywords: COVID-19, Herb, Medicinal Plant, Viral Infection and Thailand



1. Introduction

Pandemics are as old as humanity, and since ancient times, we have turned to plants to find solutions to health-related problems. Traditional medicines based mostly on plants are still the only therapeutic possibility in many developing countries, but even in the richest ones, herbal formulations currently receive increased attention [1]. Despite the significant development of modern medicine in many fields such as microbiology, chemotherapy, or cardiology, we are still struggling with the serious problem of the selectivity of the used compounds. The major problem is the high toxicity of the novel pharmaceuticals against normal cells and more cost [2] [3] and [4]. Thus, one of the most fundamental goals of modern pharmacology is to discover new biologically active compounds capable of performing a wide range of functions with minimal side effects and at a lower cost [2] [5] and [6]. Recently, a significant increase in interest in plants and the possibility of using natural compounds of plant origin in medicine has been observed during the COVID-19 pandemics [7]. It has been observed that plants are a vital component of our daily diet and an essential source of compounds of natural origin with excellent biological properties [8]. Various medicinal products of plant origin are the foundation of today's pharmaceutical industry [9] and [10].

During the COVID-19 period, there was evidence from several studies that a few types of herbs had the possibility of being natural therapeutics against the COVID-19 pandemic, such as: *Artemisia annua* [9] [11] and [12], *Cannabis indica* [13] [14] and [15], *Tiliacora triandra* [16], *Harrisonia perforate* (Blanco) Merr [17], *Tacca leontopetaloides* [18], *Ficus carica* [19] and [20], *Capparis micracantha*, *Terminalia chebula*, *Terminalia bellirica* [21] [22] and [23], *Phyllanthus emblica* [19], *Andrographis paniculate* [24], *Santalum album* [25] and [26], *Clausens wallichii* Oliv. Var. *guillauminii* (Tanaka) J.P.Molino [27], *Combretum attenuatum laccifera* Pierre [17] and [28], *Oxyceros horridus* Lour [29] and [30]. Aside the used in COVID-19 those herbs previously used for treat others.

Furthermore, in Thailand, most of the folk healers commonly use several types of medicinal plants for healing, which are beneficial for treatment and strengthening the immunity of the people in their area. In accordance with the situation of the spread of COVID-19, there are people infected in Thailand, and a large number of researchers have compiled and created a database of cumulative cases in the country. As a result, the aim of this study is to conduct a survey in terms of identifying the area where the

population commonly uses the medicinal plant in comparison to the cumulative number of COVID-19 reports in each area, including the classification of medicinal plants by type and a stepwise approach shown in the form of Geographic Information System (GIS) maps in those areas.

2. Materials and Methods

2.1 Study Design

Conducted an observational survey on the cultivation of medicinal plants those folk healers commonly used for healing. beneficial for treatment and strengthening the immunity of the people in 9 provinces of Thailand in according to the situation of the spread of COVID-19, there are people infected in Thailand (Figure 1).

2.1.1 Study area

There was conducted in Chiang Rai (Medicine Park, College of Traditional Medicine and Alternative Medicine), Chiang Mai (Thai Traditional Medicine Club and Folk Medicine Lanna), Phitsanulok (12 groups of herbal gardens and diseases, College of Medicine Sirindhorn Public Health Phitsanulok Province), Maha Sarakham (Bo Yai Subdistrict, Borabue District), Chaiyaphumi (Khun Dong Herbal Processing Community Enterprise) Sakon Nakhon (Dao Inca Community Enterprise, Phu Phan Royal Development study center) Lamphun (Pa Sang Hospital), Nakhon Phanom (Na Wa Subdistrict), Ubon Ratchatani provinces. Classified by type of medicinal plant, they were divided into 11 species by comparing the cumulative number of COVID-19 cases in the provinces in the scope of the study in 9 provinces, respectively. in the form of a geographical information map depicting those areas.

2.1.2 Population density, COVID-19 data and mapping

Population data were collected from the department of provincial administrators, ministry of Interior [31]. Thailand's COVID-19 prevalence was collected from the Department of Disease Control, Ministry of Public Health, Thailand. The Thailand map were obtained from <http://www.DIVA-GIS.org> [32]. The coordinate system UTM-1987 zone 47 north and 48 north were used. Population data, COVID-19 and maps were collected from an online database.

2.2 Data Analysis

2.2.1 Socio-demographic, prevalence used frequencies and percentages to describe COVID-19 distribution.

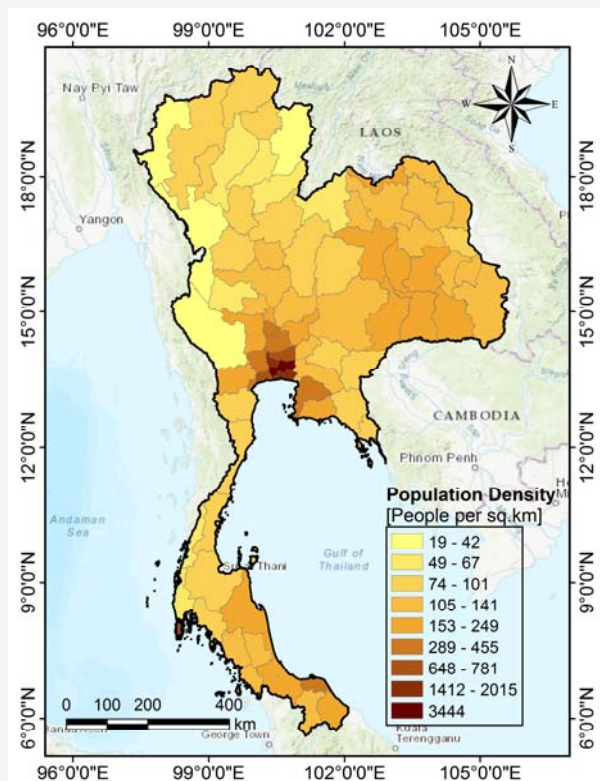


Figure 1: The population density of provinces in Thailand in October 2022

2.2.2 Spatial data

The data was modified to create geographic information using ArcGIS 10.5. The research assistant was trained to collect the coordinates position of herb in a study area. An overlay technic was performed to represent a COVID-19 distribution, herb and Traditional healers.

3. Results

During the spread of COVID-19 in Thailand, provinces with high population densities, including areas close to each other, had the highest cumulative incidence rate; however, several provinces thought to have high population densities had a low cumulative incidence rate (Figure 1). Therefore, in accordance with the results of this survey, it was found that there was a correlation between the cultivation of medicinal plants that folk healers commonly used for healing and being beneficial for treatment and strengthening the immunity of the people in the area. A large number of researchers have compiled and created a database of cumulative cases in the country. Thailand in the form of a geographical information map, classified by type of medicinal plant, divided into 11 species such as *Artemisia annua*, *Harrisonia perforate* (Blanco) Merr, *Capparis micracantha*,

Tacca leontopetaloides, *Andrographis paniculate*, *Phyllanthus emblica*, *Ficus carica*, *Tiliacora triandra*, *Terminalia chebula*, *Terminalia bellirica* and *Cannabis indica* by comparing with the cumulative number of COVID-19 cases in the provinces. in the scope of the study in 9 provinces, respectively.

3.1 Results of a Survey on the Cultivation

3.1.1 Locations of *Artemisia annua* and *Harrisonia perforate*

It was discovered that the Thai population cultivated some medicinal plants as well as *Mugwort*, a species in the genus *Artemisia Annua*. And in comparison, with the COVID-19 cumulative incidence in each area, the survey results found that there were areas where planting *mugwort* was done and that folk healers used it for treatment to strengthen the immunity of the people in the area. There was mostly reporting of low COVID-19 cumulative incidence, such as in Chiang Rai, Phitsanulok, Chaiyaphum, Nakhon Phannom, Chiang Mai, Mahasarakham, Ubon Rachathani, Sakonnakhon and Roi Et provinces (Figure 2).

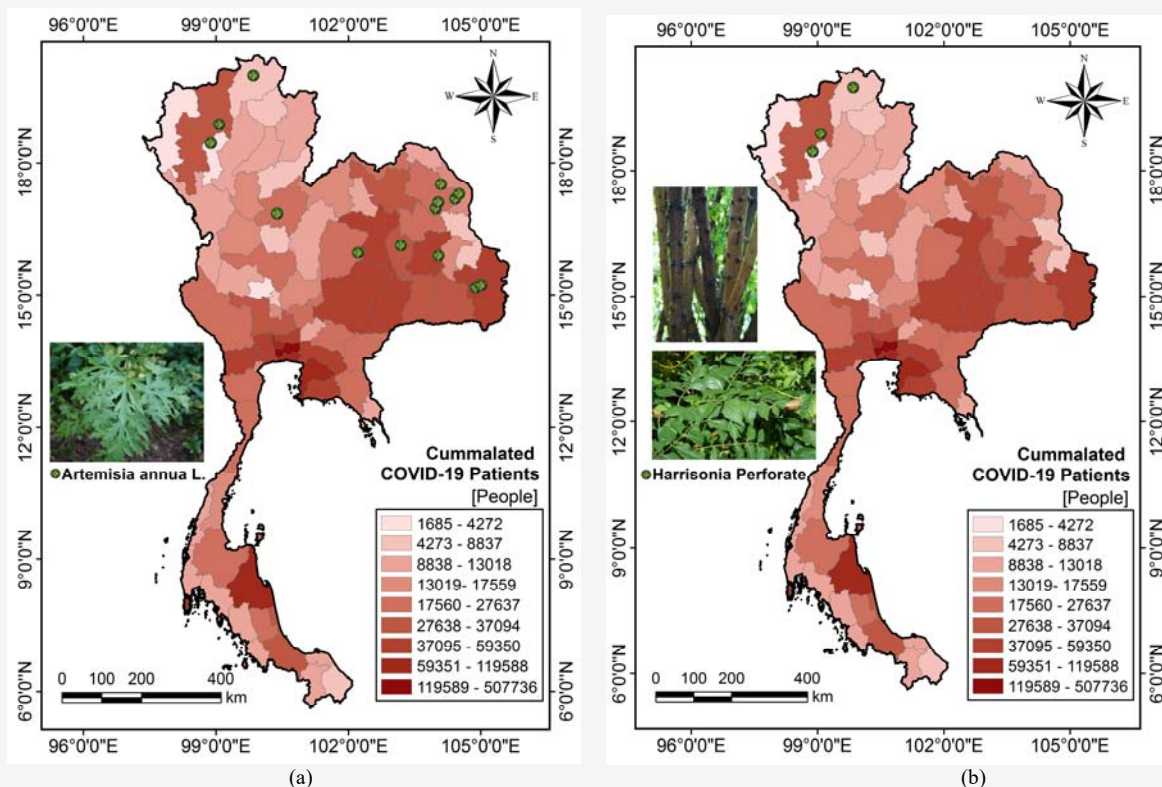


Figure 2: Planting in Thailand compared to the number of COVID-19 cases (a) *Artemisia annua* and (b) *Harrisonia perforate*

However, the *Harrisonia perforata* medicinal plant was only found in three provinces (Figure 2), including Chiang Rai province, which was localized in Medicine Park, the College of Traditional Medicine, and alternative medicine and had a low (6040 – 70301 per 100 thousand population) cumulative COVID-19 incidence; additionally, Lamphun (Pa Sang Hospital); and Chiang Mai Thai (Thai traditional medicine club and folk medicine Lanna), which had a low (6040– 70301 per 100 thousand population) cumulative COVID-19 incidence. There was evidence that the Thai population grew *Capparis micracantha* (Qingzhi) and *Tacca leontopetaloides*, the two most important medicinal herbs used to treat a variety of infections, including COVID-19. In this result of the survey, we found that the area where the population cultivated this plant for medicinal purposes was in several provinces of Thailand. According to the results of the survey on growing *Qingzhi* in Thailand, it was found that it was grown in Chiang Mai province (Thai traditional medicine club and Lanna folk medicine). The details are shown in Figure 3; furthermore, in comparison with the cumulative COVID-19 incidence rate (32923 –70301 per 100 thousand

population) reported in that province, there was a low incidences reported.

However, according to the survey results of growing *Tacca leontopetaloides* (*Thao Yai Mom*) in Thailand, it was discovered that it was planted in Chiang Rai (Medicine Park, College of Traditional Medicine and alternative medicine), Chiang Mai (Tejasit Thai Traditional Medicine Clinic), and Maha Sarakham provinces (Bo Yai Subdistrict, Borabue District), details of which are shown in Figure 3. In comparison, with the cumulative COVID-19 incidence reported, there were very low incidence rates (6040 –70301 per 100 thousand population) reported.

3.1.2 Locations of of *Capparis indica* and *Capparis micracantha* (Qingzhi) and *Tacca leontopetaloides*. There was evidence that the Thai population grew *Capparis micracantha* (Qingzhi) and *Tacca leontopetaloides*, the two most important medicinal herbs used to treat a variety of infections, including COVID-19. In this result of the survey, we found that the area where the population cultivated this plant for medicinal purposes was in several provinces of Thailand.

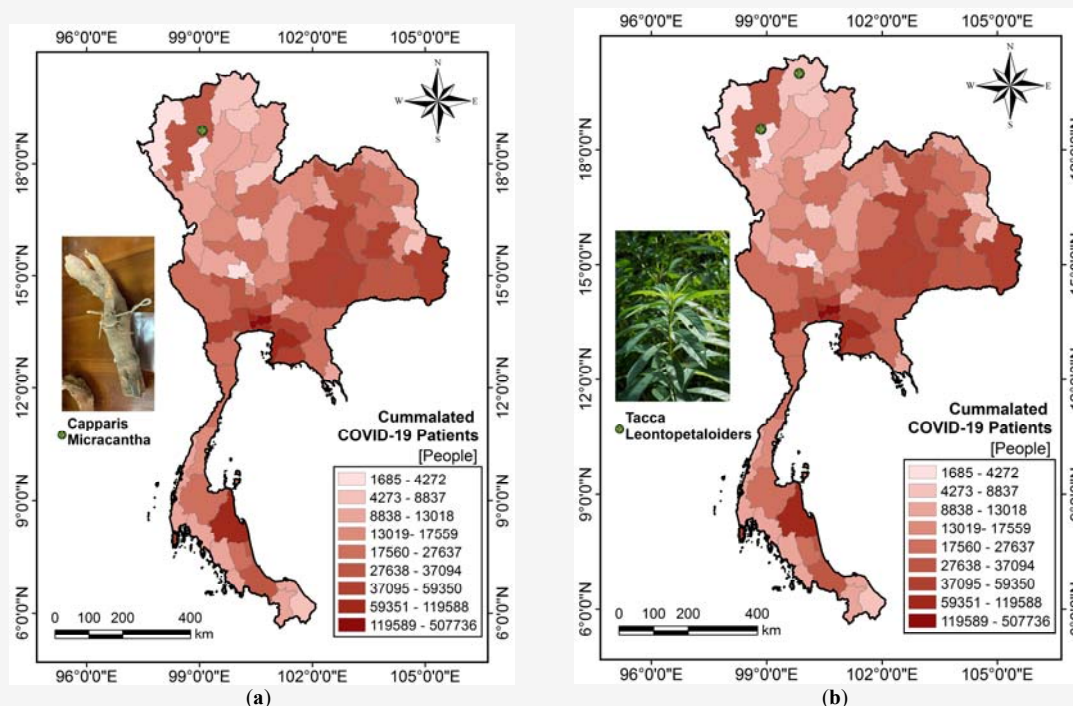


Figure 3: Planting in Thailand compared to the number of COVID-19 cases
(a) *Capparis micracantha* and (b) *Tacca leontopetaloides*

According to the results of the survey on growing *Qingzhi* in Thailand, it was found that it was grown in Chiang Mai province (Thai traditional medicine club and Lanna folk medicine). The details are shown in Figure 3(a); furthermore, in comparison with the cumulative COVID-19 incidence rate (32923 – 70301 per 100 thousand population) reported in that province, there was a low incidences reported. However, according to the survey results of growing *Tacca leontopetaloides* (*Thao Yai Mom*) in Thailand, it was discovered that it was planted in Chiang Rai (Medicine Park, College of Traditional Medicine and alternative medicine), Chiang Mai (Tejasit Thai Traditional Medicine Clinic), details of which are shown in Figure 3(b). In comparison, with the cumulative COVID-19 incidence reported, there were very low incidence rates (6040 – 70301 per 100 thousand population) reported.

3.1.3 Locations of *Andrographis paniculata* and *Phyllanthus emblica*

Fah Talai Jone (*Andrographis paniculata*) planting in Thailand, it was found that it was grown in Chiang Rai (Medicine Park, College of Traditional Medicine and Alternative Medicine), Chiang Mai (Chiang Dao District), Phitsanulok (herb garden for 12 disease groups, Sirindhorn College of Public Health, Phitsanulok Province), Lamphun (Pa Sang Hospital), Maha Sarakham (along the canal Somthawin), and Nakhon Phanom with details as shown in Figure 4(a)

provinces. In comparison with the cumulative COVID-19 incidence reported, there were a low (6040 – 70301 per 100 thousand population) incidences reported, such as in Chiang Rai, Phitsanulok, Lamphun, Nakhon Phanom, Sakhon Nakhon, and Chaiyaphum provinces, there was a very low cumulative COVID-19 incidence reported. Nevertheless, in Chiang Mai, Maha Sarakham, and Ubon Ratchathani, there was a low cumulative COVID-19 incidence reported. For further Makhampom (*Phyllanthus emblica*) planting in Thailand, it was found that it was grown in Chiang Rai, Chiang Mai, Phitsanulok, Chaiyaphum, Ubon Ratchathani, and Nakhon Phanom provinces, details of which are shown in Figure 4(b). In comparison with the cumulative COVID-19 rates in each area, there was a low (6040 – 70301 per 100 thousand population) incidence rate.

3.1.4 Locations of *Ficus carica* and *Tiliacora triandra* in Thailand

According to the findings of a survey of Chumphon figs in Thailand (*Ficus carica*), they were grown in Chiang Rai, Phitsanulok, Sakhon Nakhon, Nakhon Phanom, and Ubon Ratchathani provinces, as shown in Figure 5 and are one of the traditional medicinals that folk healers commonly use for healing. beneficial for treatment and strengthening the immunity of the people in the area.

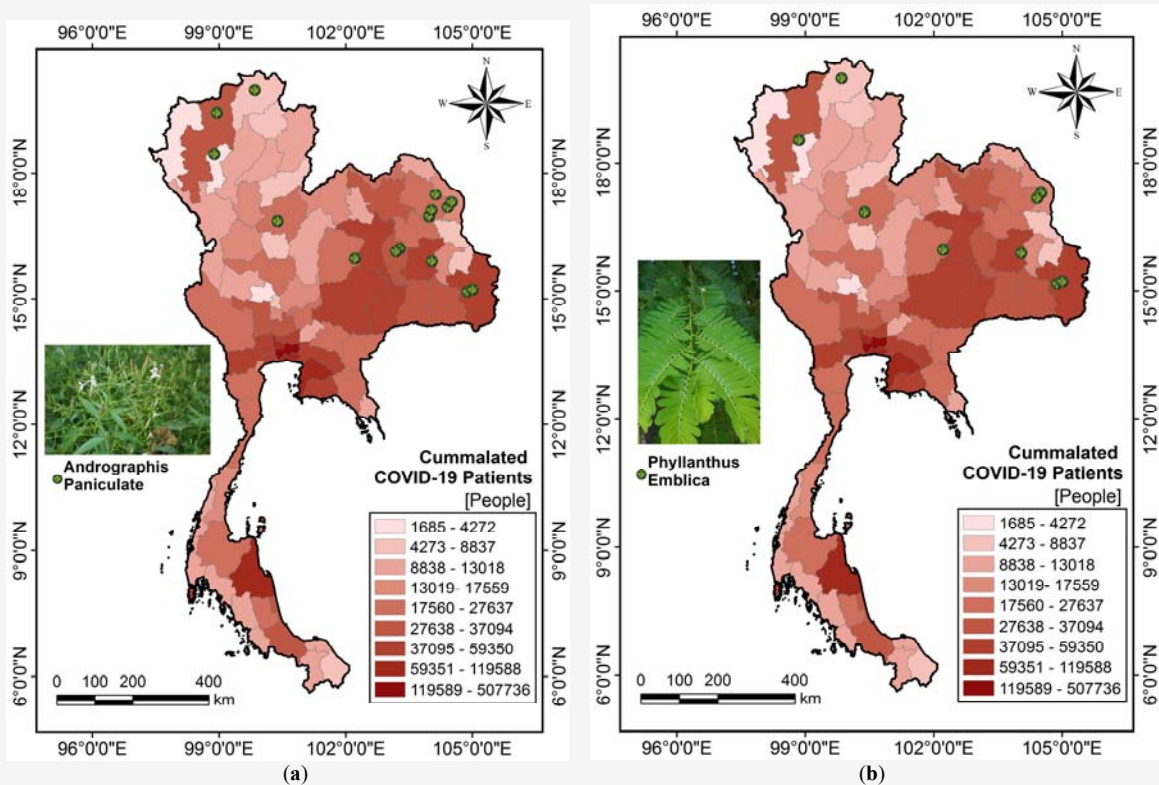


Figure 4: Planting in Thailand compared to the number of COVID cases
(a) *Andrographis paniculate* and (b) *Phyllanthus emblica*

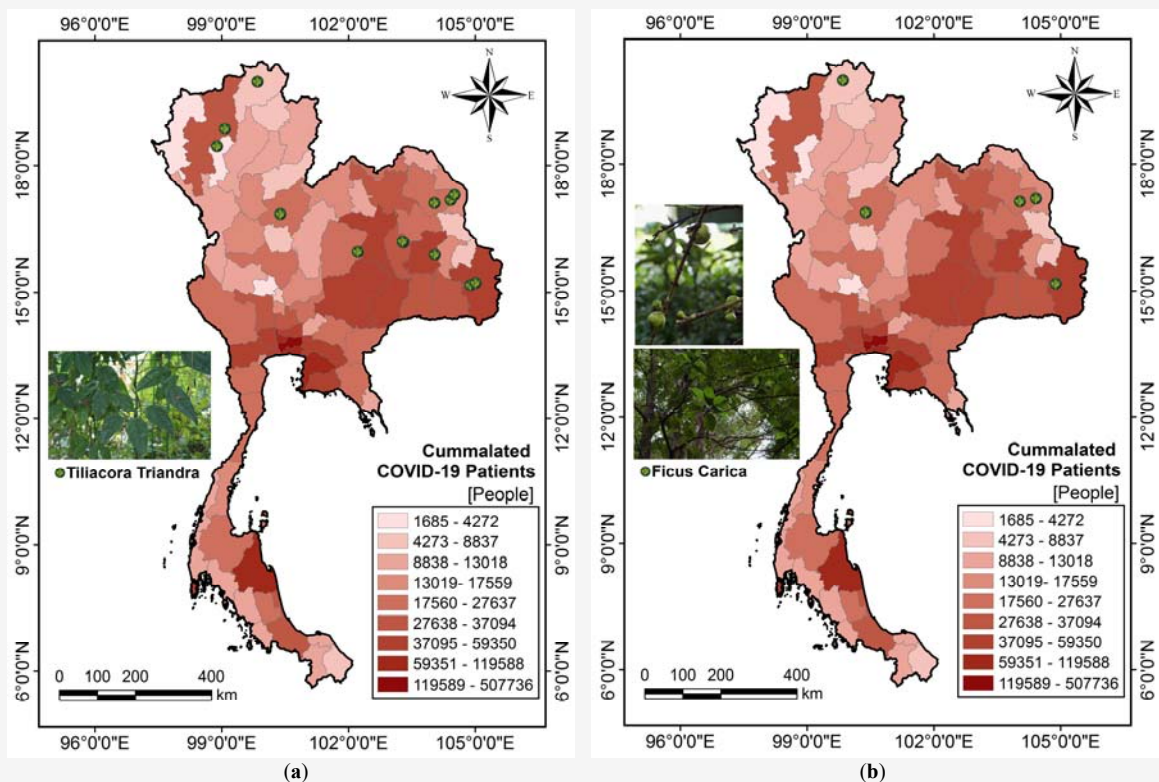


Figure 5: Planting in Thailand compared to the number of COVID-19 cases
(a) *Tiliacora triandra* and (b) *Ficus carica*

In accordance with the cumulative COVID-19 incidence reported in each area, there was mostly a very low (6040 – 32922 per 100 thousand population) and low (32923 – 70301 per 100 thousand population) incidence rate reported, such as very low in Chiang Rai, Phitsanulok, Sakon Nakhon, and Nakhon Phanom, and a low cumulative COVID-19 incidence rate in Ubon Ratchatani provinces.

Further, Yanang (*Tiliacora triandra*) plants from the results of the survey in Thailand, it was found that it was planted in Chiang Rai, Chiang Mai, Lamphun, Phitsanulok, Chaiyaphum, Maha Sarakham, Sakon Nakhon, Nakhon Phanom, and Ubon Ratchatani provinces, details of which are shown in Figure 5. In accordance with the cumulative COVID-19 incidence reported in each area planted, there was mostly a very low (6040 – 32922 per 100 thousand population) and low (32923 – 70301 per 100 thousand population) incidence rate reported, such as in Chiang Rai, Phitsanulok, Sakon Nakhon, and Nakhon Phanom, with a very low cumulative COVID-19 incidence rate, and a low cumulative COVID-19 incidence rate in Maha Sarakham, Roi Et, and Ubon Ratchatani provinces.

3.1.5 Locations of *Terminalia chebula* and *Terminalia belliria* in Thailand

Thai anchor planting in Thailand revealed that it was planted in Lamphun, Phitsanulok, Chaiyaphum, Sakon Nakhon, Nakhon Phanom, and Ubon Ratchatani provinces, with details as shown in Figure 6. In comparison with the cumulative COVID-19 incidence in each area, there was a very low incidence rate founded on a range between (6040 – 70301 per 100 thousand population), with a low cumulative incidence rate in Lamphun, Phitsanulok, Chaiyaphum, Sakon Nakhon, and Nakhon Phanom provinces and a low cumulative COVID-19 incidence rate in Ubon Ratchatani provinces. as well as the Samo Pipek (*Terminalia belliria*) plantation where it was discovered, which is one of the traditional medicinals that folk healers commonly use for healing and strengthening the immunity of the people in the area. And evidence shows that there are areas with a low cumulative COVID-19 incidence rate, such as in Chiang Rai, Chiang Mai, and Phitsanulok, Sakon Nakhon, Nakhon Phanom, and Ubon Ratchatani provinces, details of which are shown in Figure 6.

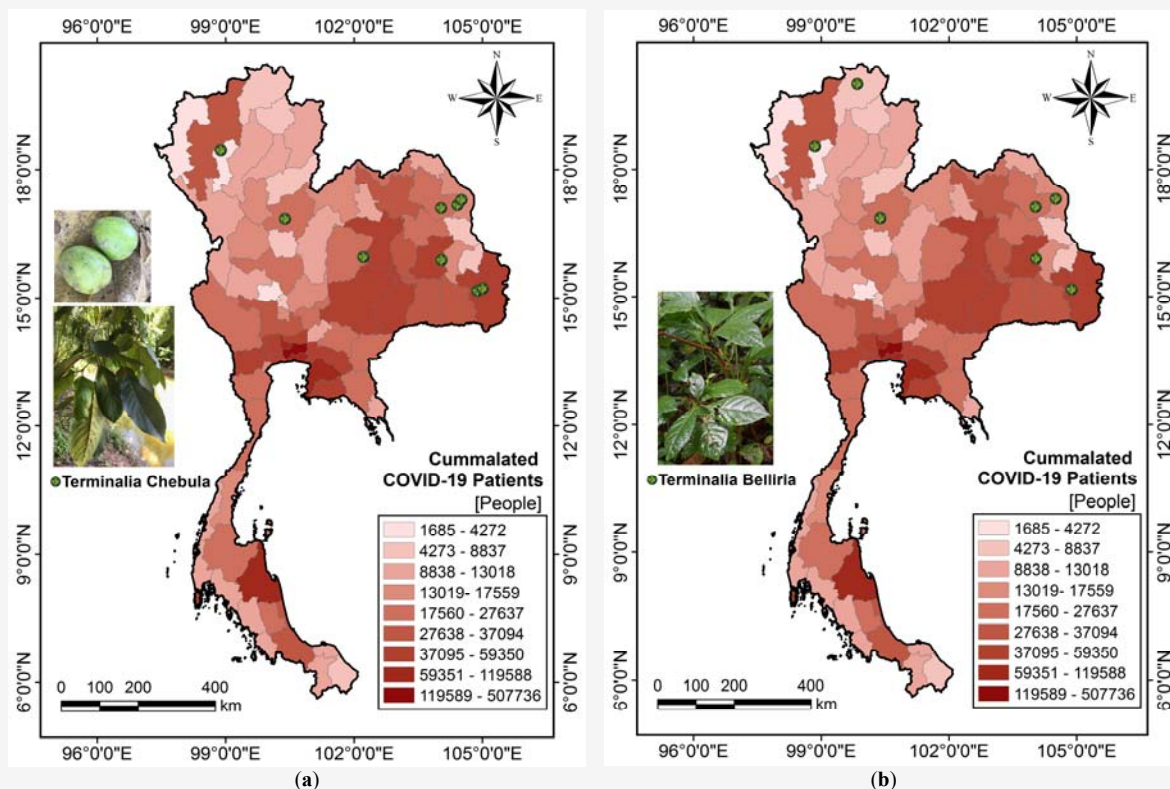


Figure 6: Planting in Thailand compared to the number of COVID cases
(a) *Terminalia chebula* and (b) *Terminalia belliria*

3.1.6 Locations of cannabis cultivation in Thailand

According to the results of a survey of *cannabis* in Thailand, it was found that it was grown in Chiang Rai, Chiang Mai, and Phitsanulok provinces, details of which are shown in Figure 7. Those areas where planting was discovered in comparison to the cumulative COVID-19 incidence found there had a low incidence rate ranging between (6040-70301 per 100 thousand population).

3.2 Locations of Medicinal Herbs for Healing COVID-19

3.2.1 Results of a survey on the cultivation of herbs that treat Covid-19 disease in Thailand

According to the results of a survey of the cultivation of medicinal herbs for Covid-19 treatment in Thailand, it was found that they were grown in the northern and northeastern regions are Chiang Rai, Chiang Mai, Phitsanulok, Lamphun, Maha Sarakham, Kalasin, Sakon Nakhon, Ubon Ratchathani, and Chaiyaphum with details as shown in Figure 8.

3.2.2 Map showing the location of indigenous healers of provinces in Thailand

The survey map shows the location of folk healers who have knowledge of Thai herbs that can cure COVID-19, classified by provinces in the northeast of Thailand, divided into 3 provinces: Nakhon

Phanom Phitsanulok Province and Ubon Ratchathani province the details are shown in Figure 9 and Figure 10.

3.2.3 Map showing the locations of folk healers and Thai herbs that treat COVID-19 in provinces in Thailand

Survey map showing Thai herbs that can cure COVID-19 of Traditional healers in different districts of Ubon Ratchathani Province and Chiang Mai Province, Thailand, including Chiang Dao District, San Sai District and Doi Lo district the details are shown in Figure 11 and Figure 12. Therefore, regarding this survey result, it is evident that we found that commonly used medicinal plants that folk healers commonly use for healing were beneficial for treatment and strengthening the immunity of the people during the COVID-19 pandemic in Thailand, such as *Artemisia annua*, *Harrisonia perforata*, *Capparis micracantha*, *Tacca leontopetaloides*, *Andrographis paniculata*, *Phyllanthus emblica*, *Ficus carica*, *Tiliacora trianga*, *Terminalia chebula*, *Terminalia bellirica*, and *Cannabis indica*, in terms of advancement and development, represent a modern farmaceutic novelty for COVID-19 treatment that is emerging as a result of the significance of this survey in each area founded on utilization and planting medicinals, which is why further discussion and research should be conducted.

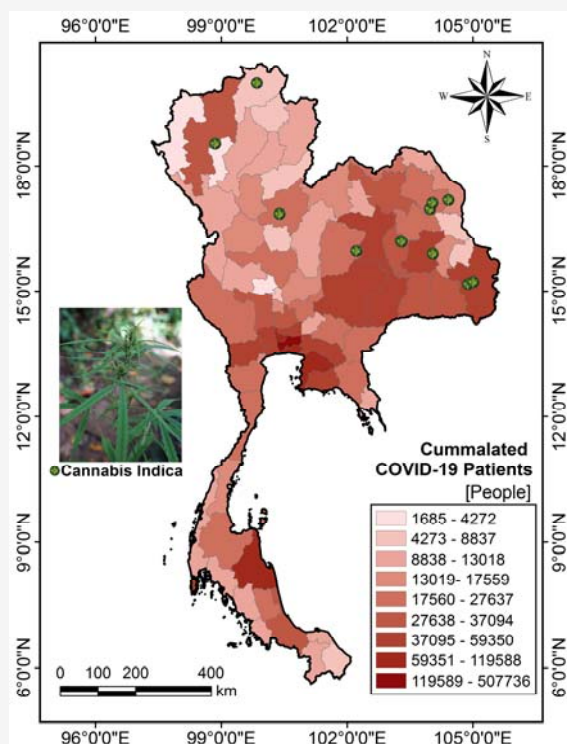


Figure 7: *Cannabis indica* planting in Thailand compared to the number of COVID cases

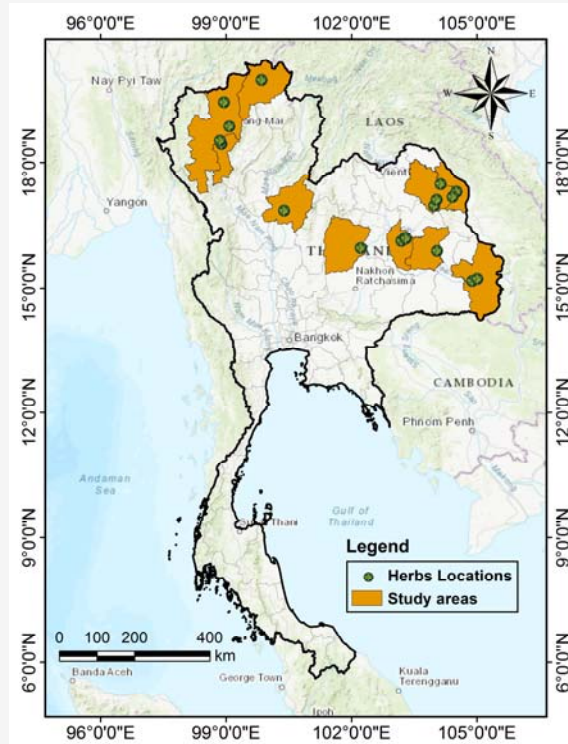


Figure 8: The coordinates of herbal planting areas used to treat Covid -19 in Thailand

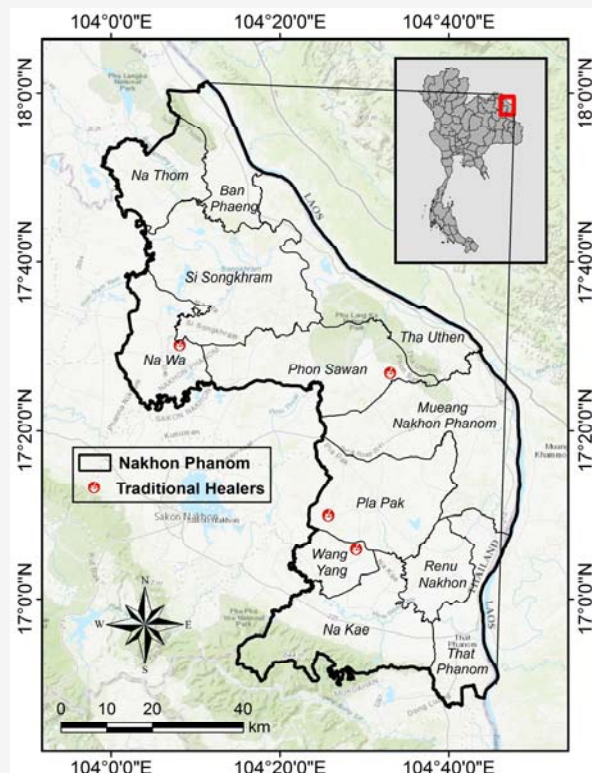


Figure 9: Map showing the survey of traditional healers in Nakhon Phanom province

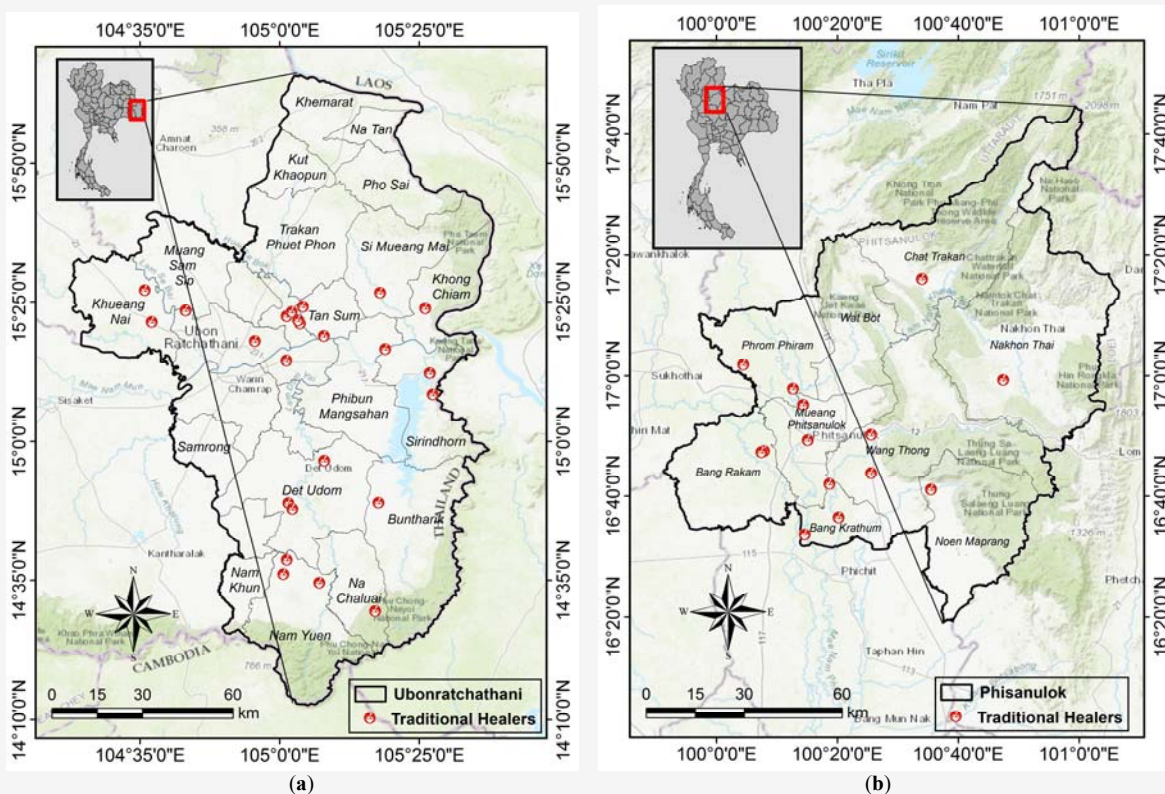


Figure 10: Locations of traditional healers (a) Ubon Ratchathani (b) Phitsanulok

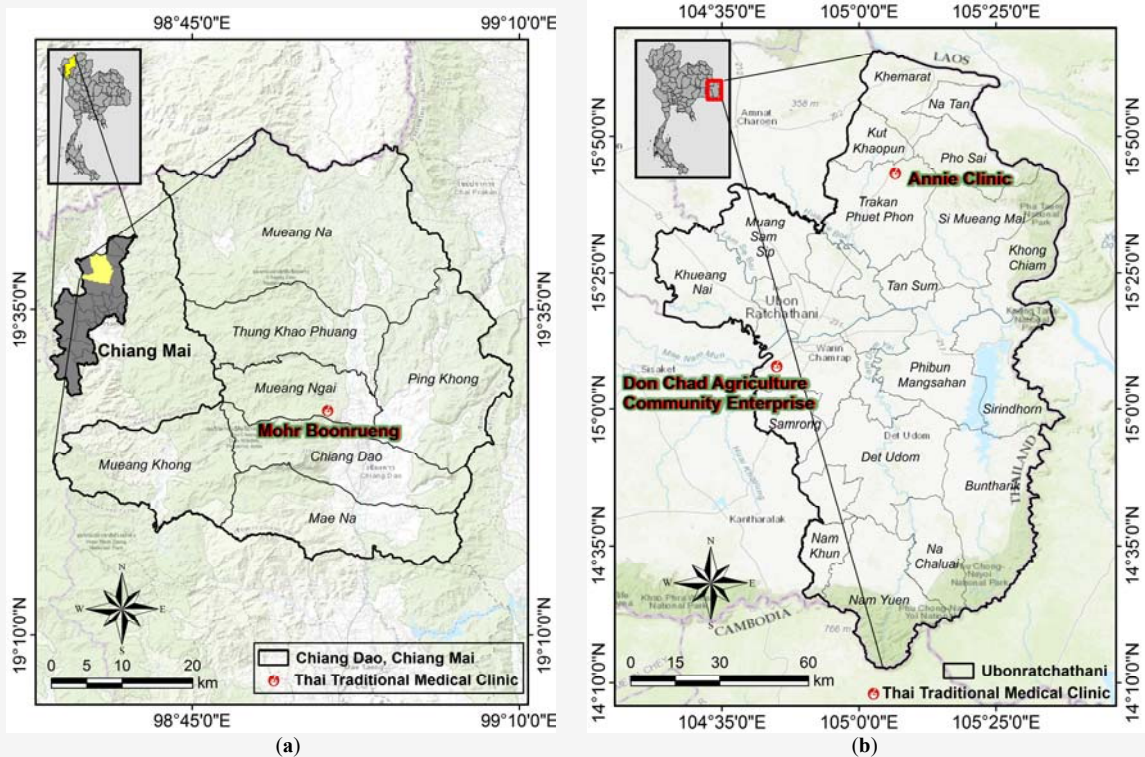


Figure 11: Survey map of herbs (a) Folk healers in Chiang Dao district, Chiang Mai province and (b) Traditional healers in Ubon Ratchathani province

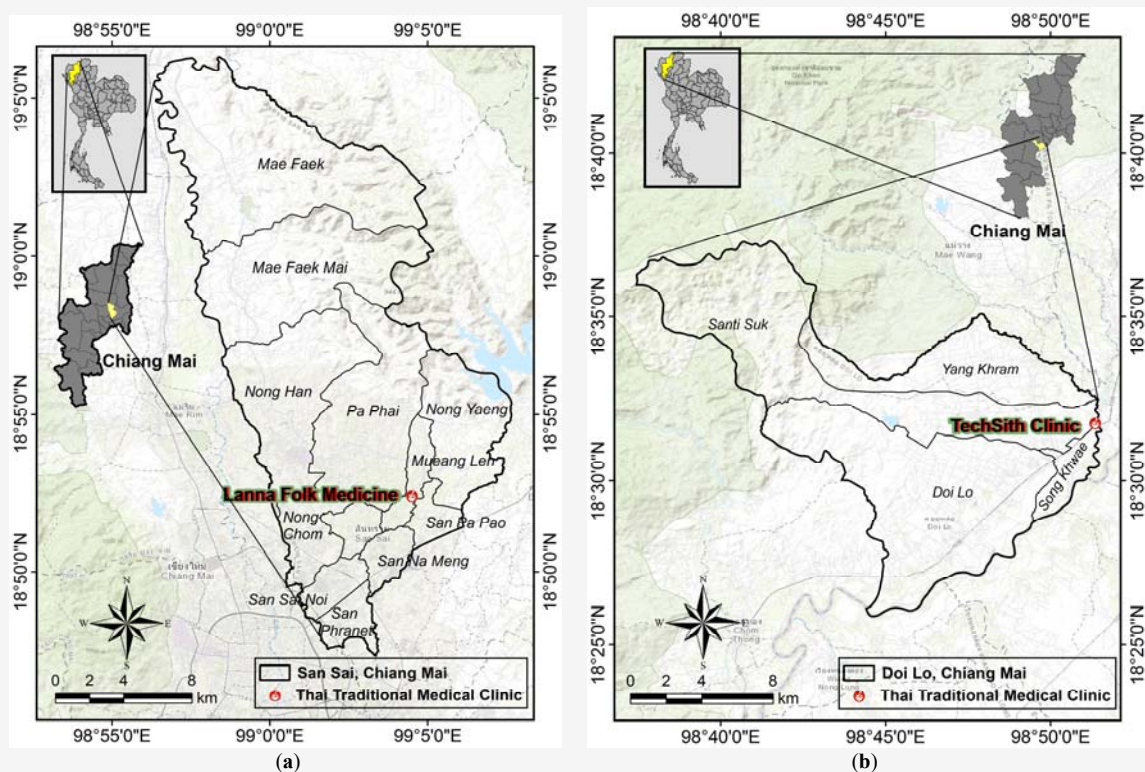


Figure 12: Survey map of herbs (a) Traditional Healers in San Sai district (b) Doi Lo district, Chiang Mai province

4. Discussions

Furthermore, the rapid outbreak of coronavirus disease 2019 (COVID-19) has demonstrated the need for the development of new vaccine candidates and therapeutic drugs to fight against the underlying virus, severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2). Currently, no antiviral treatment is available to treat COVID-19, as treatment is mostly directed at relieving the symptoms, and retrospectively, herbal medicinal plants have been used for thousands of years as a medicinal alternative, including for the treatment of various viral illnesses. However, a comprehensive description of the use of various medicinal plants in treating coronavirus infection has yet to be adequately described, particularly their modes of action.

During the spread of COVID-19 in Thailand, the cumulative COVID-19 incidence rate was mostly high in provinces with high population densities, including adjacent areas, and some provinces with high population densities that commonly used traditional medicinals had a low cumulative incidence rate. Therefore, researchers discovered that the medicinal plants commonly used by folk healers for healing are beneficial for treatment and boosting people's immunity. There was evidence that several medicinal plants were mostly used in nine provinces of Thailand, such as Chiang Rai, Chiang Mai, Lamphun, Phitsanulok, Nakhon Phanom, Maha Sarakham, Chaiyaphum, Nakhon Phanom, and Ubon Ratchatani, in comparison with the cumulative COVID-19 incidence reported in each area, respectively, in this survey result, showing that several medicinal plants for COVID-19 were mostly used in each province, there was: *Artemisia annua*, *Harrisonia perforate* (Blanco) Merr, *Capparis micracantha*, *Tacca leontopetaloides*, *Andrographis paniculate*, *Phyllanthus emblica*, *Ficus carica*, *Tiliacora triandra*, *Terminalia chebula*, *Terminalia belliria* and *Cannabis indica* in comparison with the cumulative COVID-19 incidence presented, there were mostly low incidence rates. This finding is in accordance with the preview studies [11] [12] [13] [14] [25] [31] and [32]. Therefore, the researchers assumed that those are strong candidate treatments, including transformation to modern medicine for further COVID-19 or other relevant viral pandemic treatments.

Artemisia annua *Artemisia annua* was found in several locations throughout the study area and was one of the most commonly used traditional medicines in Thailand during the COVID-19 period; the survey results showed that in those areas where it was used, there was a low incidence rate when compared to the cumulative COVID-19 incidence in these areas.

Artemisia annua has been used for the treatment of various diseases since ancient times, such as having been revealed to have inhibitory effects against parasites (e.g., *Plasmodium* spp, *Toxoplasma gondii*, *Leishmania* spp), viruses (e.g., hepatitis A virus, herpes simplex viruses 1 and 2, human immunodeficiency virus), and fungi (*Candida*, *Malassezia*, *Saccharomyces* spp) and bacteria (e.g., *Enterococcus*, *Streptococcus*, *Staphylococcus*, *Bacillus*, *Listeria*, *Haemophilus*, *Escherichia*, *Pseudomonas*, *Klebsiella*, *Acinetobacter*, *Salmonella*, and *Yersinia* spp.) [9]. However, recently, *Artemisia annua*, including other specie such as *Artemisia afra*, has been discovered to exhibit positive effects against severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) infection and COVID-19-related symptoms and is one of the potential herbal extracts that play a role in viral attachment and penetration, viral RNA and protein synthesis inhibition, inhibition of viral key proteins such as 3-chymotrypsin-like cysteine protease (3CLpro) and papain-like protease 2 (PLpro), as well as other mechanisms such as viral release inhibition and enhanced host immunity, including anti-inflammatory effects [33] [35] and [36].

Harrisonia perforate (Blanco) Merr, a medicinal plant discovered in all areas of the survey, was one of the most commonly used medicinal plants for healing by folk healers during the COVID-19 pandemic. The survey resulted in a low rate of cumulative incidence when compared to the cumulative COVID-19 incidence in each area discovered with *Harrisonia perforata* as a medicinal plant. This is consistent with the findings of Phumthum's (2020) and Tang et al.'s (2021) studies, which identified *Harrisonia perforate* (Blanco) Merr as a medicinal plant species used to treat infection-related diseases [37] and [38]. Therefore, this medicinal plant is necessary for advancement in development and represents a modern pharmaceutical novelty, particularly against viral infections with characteristics similar to those of COVID-19.

Andrographis paniculate, it was one of the common folk healers used in Thailand to treat a several infection diseases thereby, and the survey result showed in this study evidentially, the area where found this medicinal plant was presented low cumulative COVID-19 incidence this result in accordance with several studies showing that *Andrographis paniculate* (AP) (Kalmegh) were isolated the Bioactive *Andrographolide* (AGL; C20H30O5) is a diterpenoid lactones having multifunctional medicinal properties including anti-manic, anti-inflammatory, liver, and lung protective.

Andrographolide (AGL) is known for its immunostimulant activity against a variety of microbial infections thereby, regulating classical and alternative macrophage activation, Ag-specific antibody production during immune disorder therapy. therefore regarding the result in accordance the possible role of AGL as a promising herbal-chemo remedy during human diseases, viral infections and as an immunity booster [21] and [24].

Phyllanthus emblica, which is commonly used in Thailand, produced a significant result when compared to the COVID-19 cumulative incidence in each area studied; thus, according to Varnasseri et al., [39] study, organic herbal *Phyllanthus emblica* (Amla) tea may reduce symptom recovery times and length of stay (LOS) in hospital in COVID-19 patients, and it showed an ameliorative effect on the severity of clinical signs and CRP levels, although it cannot significantly affect the RT-PCR results or degree of lung involvement. Furthermore, *Phyllanthus emblica* contains particular bioactive compounds such as chlorogenic acid, quercitrin, myricetin, 7-ketositosterol, quercetin, epigallocatechin, and phyllaemblic, which play an important role in the virus and were most effective in showing the highest binding energy against the protein targets of SARS-CoV-2 and inhibiting the COVID-19 activity by binding to it [40] [41] and [42]. Therefore, the current pharmacoinformatic approach shows a possible role for *Phyllanthus emblica* in the treatment and management of COVID-19.

Ficus carica is one of several medicinal plants commonly used by folk healers for healing and beneficial treatment, including strengthening people's immunity during the COVID-19 pandemic in Thailand, with survey results showing that the cumulative incidence rate of COVID-19 was low in each area where this herb was used. This is consistent with the findings of Ahmad et al., [25], who discovered that during the COVID-19 pandemic, *Ficus carica* (tea) was used to treat respiratory disorders alongside antivirals, including anti-allergic drugs [25] and [43]. *Terminalia chebula* was one of the most commonly used medicinal plants by folk healers in Thailand during the COVID-19 pandemic, and as evidenced by this survey result, the provinces that used this medicinal plant had a low cumulative COVID-19 incidence. *Terminalia chebula* was previously used in the management of various diseases, and in accordance with the bioactive polysaccharide contained, a study by Nosalova et al. [44] used it as well as an antitussive, and the result showed that cough efforts decreased significantly. Therefore, this medicinal plant is necessary for advancement in development and represents a

modern pharmaceutical novelty for COVID-19 treatment. This is consistent with a study by Haque et al., [45] reporting that the medicinal plant *Terminalia chebula* has established antiviral activity, particularly against viral infections with characteristics similar to those of COVID-19.

Cannabis indica was found to have a significant effect in this study. The area surveyed found the *cannabis* plant and one of the medicinal herbs used in Thailand. We discovered that during the COVID-19 pandemic, folk healers used this medicinal plant for healing and strengthening immunity in several places in Thailand, and there was a low incidence rate presented in comparison to the cumulative COVID-19 incidence reported in these areas, in accordance with Hussain's et al., [47] study. Assessing the properties of cannabis is significantly more difficult than studying its individual components, and there is still a pressing need for more clinical trials, which would help determine the full potential of this plant both in the case of COVID-19 and many other disorders [46]. Several studies, however, have hypothesized that the *cannabis* plant contains specific bioactive compounds, such as Phytocannabinoids, that play an important role as well as an anti-inflammatory function in relation to the inflammatory events that occur during severe COVID-19 disease, and that cannabinoids may help to prevent the progression from mild to severe disease [13] [15] [47] and [48]. Furthermore, systemic studies are required to determine the best efficacy and toxic effects, which will be followed by large-scale preclinical trials. Our survey revealed that the proposed plants metabolites can serve as potential anti- SARS-CoV-2 lead molecules for further optimization and drug development processes to combat COVID-19 and future pandemics caused by viruses. This survey will stimulate further analysis by the scientific community and boost antiviral plant-based research followed by novel drug designing.

5. Conclusions

Scientists all around the world are trying to discover the most effective antiviral drug to combat SARS-CoV-2. In this situation, our study emphasized some medicinal plants that folk healers commonly used for healing and that were beneficial for treatment and strengthening the immunity of the people in the area. In the form of a geographical information map, these plants are classified by type of medicinal plant and divided into 11 species, such as *Artemisia annua*, *Harrisonia perforate* (Blanco) Merr, *Capparis micracantha*, *Tacca leontopetaloides*, *Andrographis paniculate*, *Phyllanthus emblica*, *Ficus carica*, *Tiliacora*, *Terminalia*, and *Cannabis indica*.

Furthermore, a large number of researchers have compiled and created a database of cumulative COVID-19 cases in the country (Thailand); therefore, comparing the cumulative COVID-19 case incidence rate in the scope of the study in 9 provinces, respectively, a significant positive result was found. In addition, this study exercise may lend enough credence to the potential value of Thai medicinal plants (herbs) as possible leads in anti-COVID-19 drug discovery through research and development.

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References

- [1] Garcia, S., (2020). Pandemics and Traditional Plant-Based Remedies. A Historical-Botanical Review in the Era of COVID19. *Front. Plant Sci.*, Vol. 11, 1–9, <http://doi:10.3389/fpls.2020.571042>.
- [2] Kelly, C. M. and Latimer, J. J., (2005). Unscheduled DNA Synthesis: A Functional Assay for Global Genomic Nucleotide Excision Repair. *Methods Mol. Biol.*, Vol. 291(1). 303–320. <http://doi:10.1385/1-59259-840-4:303>.
- [3] Gorey, K. M., Haji-Jama, S., Bartfay, E., Luginaah, I. N., Wright, F. C. and Kanjeekal, S. M., (2014). Lack of Access to Chemotherapy for Colon Cancer: Multiplicative Disadvantage of Being Extremely Poor, Inadequately Insured and African American. *BMC Health Serv. Res.*, Vol. 14(1), 1–7. <http://doi:10.1186/1472-6963-14-133>.
- [4] Oun, R., Moussa, Y. E. and Wheate, N. J., (2018). The Side Effects of Platinum-Based Chemotherapy Drugs: A Review for Chemists. *Dalt. Trans.*, Vol. 47(19). 6645–6653. <http://doi:10.1039/c8dt00838h>.
- [5] Ciccicarese, C., Alfieri, S., Santoni, M., Santini, D., Brunelli, M., Bergamini, C., Licitra, L., Montironi, R., Tortora, G. and Massari, F., (2016). New Toxicity Profile for Novel Immunotherapy Agents: Focus on Immune-Checkpoint Inhibitors. *Expert Opin. Drug Metab. Toxicol.*, Vol. 12(1), 57–74. <http://doi:10.1517/17425255.2016.1120287>.
- [6] Cong, Y., Han, X., Wang, Y., Chen, Z., Lu, Y., Liu, T., Wu, Z., Jin, Y., Luo, Y. and Zhang, X., (2020). Drug Toxicity Evaluation Based on Organ-On-A-Chip Technology: A Review. *Micromachines*, Vol. 11 (4), 1–24. <http://doi:10.3390/M11040381>.
- [7] Mlozi, S. H., (2022). The Role of Natural Products from Medicinal Plants against COVID-19: Traditional Medicine Practice in Tanzania. *Heliyon*, Vol. 8(6). <http://doi:10.1016/j.heliyon.2022.e09739>.
- [8] Sachan, A. K., Kumar, S., Kumari, K. and Singh, D., (2018). Medicinal Uses of Spices Used in our Traditional Culture: Worldwide. *J. Med. Plants Stud.*, Vol. 6(3), 116–122. [Online]. Available: <https://www.researchgate.net/publication/342591176>.
- [9] Feng, X., Cao, S., Qiu, F. and Zhang, B., (2020). Traditional Application and Modern Pharmacological Research of Artemisia Annua L. *Pharmacol. Ther.*, Vol. 216, <http://doi:10.1016/j.pharmthera.2020.107650>.
- [10] Patwardhan, B. and Mashelkar, R. A., (2009). Traditional Medicine-Inspired Approaches to Drug Discovery: Can Ayurveda Show the Way forward?. *Drug Discov. Today*, Vol. 14(15–16). 804–811. <http://doi:10.1016/j.drudis.2009.05.009>.
- [11] Kapepula, P. M., Kabengele, J. K., Kingombe, M., Van Bambeke, F., Tulkens, P. M., Sadiki Kishabongo, A., Decloedt, E., Zumla, A., Tiberi, S., Suleman, F., Tshilolo, L., Muyembe-Tamfum, J. J., Zumla, A. and Nachega, J. B., (2020). Derivatives for COVID-19 Treatment: Anecdotal Use, Political Hype, Treatment Potential, Challenges, and Road Map to Randomized Clinical Trials. *A. Am. J. Trop. Med. Hyg.*, Vol. 103(3). 960–964. <http://doi:10.4269/ajtmh.20-0820>.

- [12] Rolta, R., Salaria, D., Sharma, P., Sharma, B., Kumar, V., Rath, B., Verma, M., Sourirajan, A., Baumler, D. J. and Dev, K., (2021). Phytocompounds of Rheum emodi, Thymus serpyllum, and Artemisia annua Inhibit Spike Protein of SARS-CoV-2 Binding to ACE2 Receptor: In Silico Approach. *Curr. Pharmacol. Reports*, Vol. 7(4). 135–149. [http://doi: 10.1007/s40495-021-00259-4](http://doi:10.1007/s40495-021-00259-4).
- [13] Mahmud, M. S., Hossain, M. S., Ahmed, A. T. M. F., Islam, M. Z., Sarker, M. E. and Islam, M. R., (2021). Antimicrobial and antiviral (SARS-CoV-2) Potential of Cannabinoids and Cannabis Sativa: A Comprehensive Review. *Molecules*, Vol. 26(23), 1–32. [http://doi: 10.3390/molecules26237216](http://doi:10.3390/molecules26237216).
- [14] Deguchi, M., Kane, S., Potlakayala, S., George, H., Proano, R., Sheri, V., Curtis, W. R. and Rudrabhatla, S., (2020). Metabolic Engineering Strategies of Industrial Hemp (Cannabis sativa L.): A Brief Review of the Advances and Challenges. *Front. Plant Sci.*, Vol. 11. <http://doi:10.3389/fpls.2020.580621>.
- [15] Santos, S., Barata, P., Charmier, A., Lehmann, I., Rodrigues, S., Melosini, M. M., Pais, P. J., Sousa, A. P., Teixeira, C., Santos, I., Rocha, A. C., Baylina, P. and Fernandes, R., (2021). The Immunopathology of COVID-19 and the Cannabis Paradigm. *Front. Immunol.*, Vol. 12, 1–13. <http://doi:10.3389/fimmu.2021.631233>.
- [16] Julsrigival, J., Sirisa-Ard, P., Julsrigival, S. and Akarchariya, N., (2021). Antiviral Medicinal Plants Found in Lanna Traditional Medicine, *Chinese Herb. Med.*, Vol. 13(4), 494–501. <http://doi:10.1016/j.chmed.2021.09.006>.
- [17] Attah, A. F., Fagbemi, A. A., Olubiyi, O., Dada-Adegbola, H., Oluwadotun, A., Elujoba, A. and Babalola, C. P., (2021). Therapeutic Potentials of Antiviral Plants Used in Traditional African Medicine with COVID-19 in Focus: A Nigerian Perspective. *Front. Pharmacol.*, Vol. 12, 1–38. <http://doi:10.3389/fphar.2021.596855>.
- [18] Chikowe, I., Mtewa, A. G., Tembo, D., Smith, D., Ibrahim, E., Mwamatope, B., Nkhungulu, J., Kumpalume, P. and Maroyi, A., (2021). Potential of Malawi's Medicinal Plants in Covid-19 Disease Management: A Review. *Malawi Med. J.*, Vol. 33(2). 85–107. [http://doi: 10.4314/mmj.v33i2.4](http://doi:10.4314/mmj.v33i2.4).
- [19] Issa, S. S., Sokornova, S. V., Zhidkin, R. R. and Matveeva, T. V., (2022). The Main Protease of SARS-CoV-2 as a Target for Phytochemicals against Coronavirus. *Plants*, Vol. 11(14). [http://doi: 10.3390/plants11141862](http://doi:10.3390/plants11141862).
- [20] V. A. Tirado-Kulieva, E. Hernández-Martínez, and T. J. Choque-Rivera, (2022). Phenolic Compounds versus SARS-CoV-2: An Update on the Main Findings against COVID-19. *Heliyon*, Vol. 8(9). <http://doi:10.1016/j.heliyon.2022.e10702>.
- [21] Imran, M., Khan, S. A., Abida, Alshammari, M. K., Alkhaldi, S. M., Alshammari, F. N., Kamal, M., Alam, O., Asdaq, S. M. B., Alzahrani, A. K. and Jomah, S., (2022). Nigella sativa L. and COVID-19: A Glance at the Anti-COVID-19 Chemical Constituents, Clinical Trials, Inventions, and Patent Literature. *Molecules*, Vol. 27(9). <http://doi:10.3390/molecules27092750>.
- [22] Nikhat, S. and Fazil, M., (2022). Therapeutic and Palliative Role of a Unani Herbal Decoction in COVID-19 and Similar Respiratory Viral Illnesses: Phytochemical & Pharmacological Perspective. *Journal of Ethnopharmacology*, Vol. 297. <https://doi.org/10.1016/j.jep.2022.115526>.
- [23] Ali, S. I., Sheikh, W. M., Rather, M. A., Venkatesalu, V., Muzamil Bashir, S. and Nabi, S. U., (2021). Medicinal Plants: Treasure for Antiviral Drug Discovery. *Phyther. Res.*, Vol. 35(7), 3447–3483. [http://doi: 10.1002/ptr.7039](http://doi:10.1002/ptr.7039).
- [24] Mishra, A., Shaik, H. A., Sinha, R. K. and Shah, B. R., (2021). Andrographolide: A Herbal-Chemosynthetic Approach for Enhancing Immunity, Combating Viral Infections, and Its Implication on Human Health. *Molecules*, Vol. 26(22). <http://doi:10.3390/molecules26227036>.
- [25] Ahmad, S., Zahiruddin, S., Parveen, B., Basist, P., Parveen, A., Gaurav, Parveen, R. and Ahmad, M., (2021). Indian Medicinal Plants and Formulations and their Potential Against COVID-19-Preclinical and Clinical Research. *Frontiers in pharmacology*, Vol. 11. <https://doi.org/10.3389/fphar.2020.578970>.
- [26] Khan, F., Ansari, A. N. and Nayab, M., (2021). Rationalistic Approach in COVID-19 Prevention Through Intervention of Unani Medicine Prevalent in Epidemic – A Review. *Journal of Herbal Medicine*, Vol.30 (1). <https://doi.org/10.1016/j.hermed.2021.100515>.
- [27] Gomes, P. W. P., Martins, L., Gomes, E., Muribeca, A., Pamplona, S., Komesu, A., Bichara, C., Rai, M., Silva, C. and Silva, M., (2022). Antiviral Plants from Marajó Island, Brazilian Amazon: A Narrative Review. *Molecules*, Vol. 27(5). <http://doi:10.3390/molecules27051542>.

- [28] Abiri, R., Abdul-Hamid, H., Sytar, O., Abiri, R., Bezerra de Almeida, E. Jr., Sharma, S. K., Bulgakov, V. P., Arroo, R. R. J. and Malik, S. A., (2021). A Brief Overview of Potential Treatments for Viral Diseases Using Natural Plant Compounds: The Case of SARS-Cov. *Molecules*, Vol. 26(13). <https://doi.org/10.3390/molecules26133868>.
- [29] Hafez Ghoran, S., El-Shazly, M., Sekeroglu, N. and Kijjoa, A., (2021). Natural Products from Medicinal Plants with Anti-Human, *Molecules*, Vol. 26(6), 1–28. <https://doi.org/10.3390/molecules26061754>.
- [30] Wani, A. R., Yadav, K., Khursheed, A. and Rather, M. A., (2021). An Updated and Comprehensive Review of the Antiviral Potential of Essential Oils and their Chemical Constituents with Special Focus on their Mechanism of Action Against Various Influenza and Coronaviruses. *Microbial Pathogenesis*, Vol. 152. <https://doi.org/10.1016/j.micpath.2020.104620>.
- [31] Department of Provincial Administration, (2020). Registry Statistic System. [Online]. Available: <http://stat.dopa.go.th/stat/statnew/statMenu/newStat/home.php>.
- [32] DIVA-GIS, (2020). Thailand Boundary. [Online]. Available: https://data.biogeo.ucdavis.edu/data/diva/adm/THA_adm.zip.
- [33] Farmanpour-Kalalagh, K., Beyraghdar Kashkooli, A., Babaei, A., Rezaei, A. and van der Krol, A. R., (2022). Artemisinins in Combating Viral Infections Like SARS-CoV-2, Inflammation and Cancers and Options to Meet Increased Global Demand. *Front. Plant Sci.*, Vol. 13, 1–22. <http://doi:10.3389/fpls.2022.780257>.
- [34] Daniell, H., Nair, S. K., Esmaeili, N., Wakade, G., Shahid, N., Ganesan, P. K., Islam, M. R., Shepley-McTaggart, A., Feng, S., Gary, E. N., Ali, A. R., Nuth, M., Cruz, S. N., Graham-Wooten, J., Streatfield, S. J., Montoya-Lopez, R., Kaznica, P., Mawson, M., Green, B. J., Ricciardi, R., Milone, M., Harty, R. N., Wang, P., Weiner, D. B., Margulies, K. B. and Collman, R. G., (2022). Debulking SARS-CoV-2 in Saliva Using Angiotensin Converting Enzyme 2 in Chewing Gum to Decrease Oral Virus Transmission and Infection. *Molecular Therapy*, Vol. 30(5). 1966–1978. <https://doi.org/10.1016/j.ymthe.2021.11.008>.
- [35] Remali, J. and Aizat, W. M. A., (2021). A Review on Plant Bioactive Compounds and their Modes of Action against Coronavirus Infection. *Front. Pharmacol.*, Vol. 11, 1–13. <http://doi:10.3389/fphar.2020.589044>.
- [36] Ugwah-Oguejiofor, C. J. and Adebisi, I. M., (2021). Potential Medicinal Plant Remedies and Their Possible Mechanisms Against COVID-19: A Review. *IFE Journal of Science*, Vol. 20 (1), 161–194. <https://doi.org/10.4314/ijss.v23i1.16>.
- [37] Phumthum, M. and Balslev, H., (2020). Anti-infectious Plants of the Thai Karen: A Meta-Analysis. *Antibiotics*, Vol. 9(6). 1–15. <http://doi:10.3390/antibiotics9060298>.
- [38] Tang, X. H., Luo, R. C., Ye, M. S., Tang, H. Y., Ma, Y. L., Chen, Y. N., Wang, X. M., Lu, Q. Y., Liu, S., Li, X. N., Yan, Y., Yang, J., Ran, X. Q., Fang, X., Zhou, Y., Yao, Y. G., Di, Y. T. and Hao, X. J., (2021). Harpertriolate A, an A, B, D-seco-Limonoid with Promising Biological Activity against Alzheimer's Disease from Twigs of *Harrisonia perforata* (Blanco) Merr. *Org. Lett.*, Vol. 23(2), 262–267. <http://doi:10.1021/acs.orglett.0c03460>.
- [39] Varnasseri, M., Siahpoosh, A., Hoseinynejad, K., Amini, F., Karamian, M., Yad, M. J. Y., Cheraghian, B. and Khosravi, A. D., (2022). Complementary Therapies in Medicine the effects of add-on therapy of *Phyllanthus Emblica* (Amla) on Laboratory Confirmed COVID-19 Cases: A Randomized, Double-Blind, Controlled Trial. *Complement. Ther. Med.*, Vol. 65. <http://doi:10.1016/j.ctim.2022.102808>.
- [40] Chikhale, R. V., Sinha, S. K., Khanal, P., Gurav, N. S., Ayyanar, M., Prasad, S. K., Wanjari, M. M., Patil, R. B. and Gurav, S. S., (2021). Computational and Network Pharmacology Studies of *Phyllanthus Emblica* to Tackle SARS-CoV-2. *Phytomedicine Plus*, Vol. 1(3). <http://doi:10.1016/j.phyplu.2021.100095>.
- [41] Murugesan, S., Kottekad, S., Crasta, I., Sreevathsan, S., Usharani, D., Perumal, M. K. and Mudliar, S. N., (2021). Targeting COVID-19 (SARS-CoV-2) Main Protease through Active Phytocompounds of Ayurvedic Medicinal Plants – *Emblica Officinalis* (Amla), *Phyllanthus niruri* Linn. (Bhumi Amla) and *Tinospora Cordifolia* (Giloy) – A Molecular Docking and Simulation Study. *Comput. Biol. Med.*, Vol. 136. <http://doi:10.1016/j.compbiomed.2021.104683>.

- [42] Tripathy, S., Verma, D. K., Thakur, M., Patel, A. R., Srivastav, P. P., Singh, S., Gupta, A. K., Chávez-González, M. L., Aguilar, C. N., Chakravorty, N., Verma, H. K. and Utama, G. L., (2021). Curcumin Extraction, Isolation, Quantification and its Application in Functional Foods: A Review with a Focus on Immune Enhancement Activities and COVID-19. *Front. Nutr.*, Vol. 8. <http://doi:10.3389/fnut.2021.747956>.
- [43] L. Ang, H. W. Lee, J. Y. Choi, J. Zhang, and M. Soo Lee, (2020). "Herbal medicine and pattern identification for treating COVID-19: a rapid review of guidelines," *Integr. Med. Res.*, vol. 9(2). 100407. <http://doi:10.1016/j.imr.2020.100407>.
- [44] Nosalova, G., Jurecek, L., Chatterjee, U. R., Majee, S. K., Nosal, S. and Ray, B., (2013). Antitussive Activity of the Water-Extracted Carbohydrate Polymer from Terminalia chebula on Citric Acid-Induced Cough. *Evid Based Complement Alternat Med.*, <http://doi:10.1155/2013/650134>.
- [45] Haque, E., Karim, A., Chowdhury, J. A., Rezwan, R. and Akter, T., (2021). CAN TERMINALIA CHEBULA (HARITAKI) STOP COVID-19?. *European Journal Pharmaceutical and Medical Research*, Vol. 8(1), 115–119.
- [46] Janecki, M., Graczyk, M., Lewandowska, A. A. and Pawlak, L., (2022). Anti-Inflammatory and Antiviral Effects of Cannabinoids in Inhibiting and Preventing SARS-CoV-2 Infection. *Int. J. Mol. Sci.*, Vol. 23(8). <http://doi:10.3390/ijms23084170>.
- [47] Hussain, T., Jeena, G., Pitakbut, T., Vasilev, N. and Kayser, O., (2021). Cannabis Sativa Research Trends, Challenges, and New-Age Perspectives. *iScience*, Vol. 24(12). <http://doi:10.1016/j.isci.2021.103391>.
- [48] Suryavanshi, S. V., Kovalchuk, I. and Kovalchuk, O., (2021). Cannabinoids as Key Regulators of Inflammasome Signaling: A Current Perspective. *Front. Immunol.*, Vol. 11, 1–20. <http://doi:10.3389/fimmu.2020.613613>.