ETHNOBOTANICAL STUDY OF MEDICINAL PLANT USAGE DURING COVID-19 PANDEMIC: A COMMUNITY-BASED SURVEY IN INDONESIA

NI MADE DWI MARA WIDYANI NAYAKA[1*], PUTU ERA SANDHI KUSUMA YUDA[1], DWI ARYMBHI SANJAYA[2], DESAK KETUT ERNAWATI[3], ERNA CAHYANINGSIH[1], NI LUH KADE ARMAN ANITA DEWI[1] AND MARIA MALIDA VERNANDES SASADARA[1]

[1]*Department of Natural Medicine, Faculty of Pharmacy, Universitas Mahasaraswati Denpasar, Denpasar, 80233, Indonesia*
[2]*Departement of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Mahasaraswati Denpasar, Denpasar, 80233, Indonesia*
[3]*Departement of Pharmacology and Therapy, Faculty of Medicine, Udayana University, Denpasar, 80232, Indonesia*

Received 21 July 2022 / Revised 1 June 2023 /Accepted 4 June 2023

ABSTRACT

Before the availability of a vaccine, Indonesian population relied on traditional medicines to prevent COVID-19. Any species used by indigenous people could lead to further investigations in modern pharmacology, to preserve ancient knowledge, and to plan for plants' conservation. The study aimed to discover and record species, methods of preparation, route of administration, and motivation in using medicinal plants by the Indonesian population during the COVID-19 pandemic. Participants of survey were selected from the people who live in Java and Bali for responding to an online structured questionnaire. Relative Frequency of Citation (RFC) was employed in the quantitative analysis of the collected data. The pharmacological relevance of the five plants with the highest RFC was further reviewed. The results showed that respondents used 59 plants from 28 families. Five species with the highest RFC were *Curcuma longa* (0.707), *Zingiber officinale* (0.674), *Cymbopogon citratus* (0.269), *Kaempferia galanga* (0.174), and *Curcuma zanthorrhiza* (0.165). Most plants were prepared by boiling (77.97%) and administered orally as a single ingredient or mixed with other herbals. Respondents believed that the plants were beneficial as immune-booster (71.26%), maintain good health (24.85%) and stamina (12.28%), and prevent viral infection, including COVID-19 (5.39%). The most commonly used plants might be scientifically based to boost immunity. However, their usage against COVID-19 and the medicinal value of herbal mixtures should be further investigated.

Keywords: COVID-19, Ethnobotany, Indonesia, Medicinal plants

INTRODUCTION

Corona Virus Disease 2019 (COVID-19) is an infectious disease caused by severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2). It was found in China in December 2019 and spread to other countries, including Indonesia. The first two confirmed COVID-19 cases in Indonesia were reported on March 2, 2020, and the numbers keep rising since then (Djalante *et al.* 2020). Based on history, previous SARS-CoV coronavirus also caused an outbreak in China in 2003. The genetic sequence analysis showed that SARS-CoV-2 was similar around 79% to SARS-CoV. Thus, most of the studies on its prevention and medication were adopted from the previous outbreak (Ghaffari *et al.* 2020).

The Indonesian Ministry of Health released health protocols to prevent and control COVID-19 (HK.01.07/MENKES/382/2020), which included the suggestion to wear masks, washing hands frequently, social distancing, and immunity enhancement through clean and healthy living behavior. During the SARS outbreak, natural medicine showed beneficial effects in preventing and treating patients, particularly in high-risk subjects (Boozari &

*Corresponding author, email: nimade.nayaka@unmas.ac.id; nimade.nayaka@gmail.com

Hosseinzadeh 2020; Y. Li *et al.* 2020). The usage of medicinal plants as a prophylaxis measure against COVID-19 was also recommended by Ayurveda and Traditional Chinese Medicine (Boozari & Hosseinzadeh 2020; Khanal *et al.* 2020; Vellingiri *et al.* 2020). Further, many studies have proven the antiviral, anti-inflammatory, and immunomodulatory properties of medicinal plants that are potentially helpful to combat viral diseases (Lin *et al.* 2014; Khanna *et al.* 2020).

Indonesia has abundant natural resources in plant species and the local people have used them as herbal remedies. Some of the ethnobotanical studies recorded the importance of Indonesian biodiversity as traditional medicines in different health conditions (Nahdi & Kurniawan 2019; Taek *et al.* 2019; Jadid *et al.* 2020). Those studies are significantly important to converse precious indigenous knowledge and publish them as academic literature. In the present study, we conducted an online survey to identify the use of medicinal plants by the Indonesian population during the COVID-19 pandemic. The comprehensive data from respondents on the species of medicinal plants, method of preparation and administration, as well as motivation to use, were documented. While antivirus and vaccines are vital, the research on natural medicine regarding COVID-19 may be used as a reference to develop new drug candidates and as home-based remedies in the future that are inexpensive, commonly, and easily implemented in society. The study aimed to discover and to record species, methods of preparation, route of administration, and motivation in using medicinal plants by the Indonesian population during the COVID-19 pandemic.

MATERIALS AND METHODS

Study Area

A survey was conducted in Java and Bali Island (Figure 1), which consist of 7 provinces, namely Special Capital Region of Jakarta (6°12'S, 106°49'E), Banten (6°30'S 106°15'E), West Java (6°45'S 107°30'E), Central Java (7°30'S 110°00'E), Special Region of Yogyakarta (7°47'S 110°22'E), East Java (7°16'S 112°45'E), and Bali (8°20'06"S 115°05'17"E). All the regions have diverse ethnicities such as Bantenese in Banten, Balinese in Bali, and Javanese in other regions. Respected to the ethnicity, each of the regions has its traditional language. However, natives speak Indonesian in their daily lives.

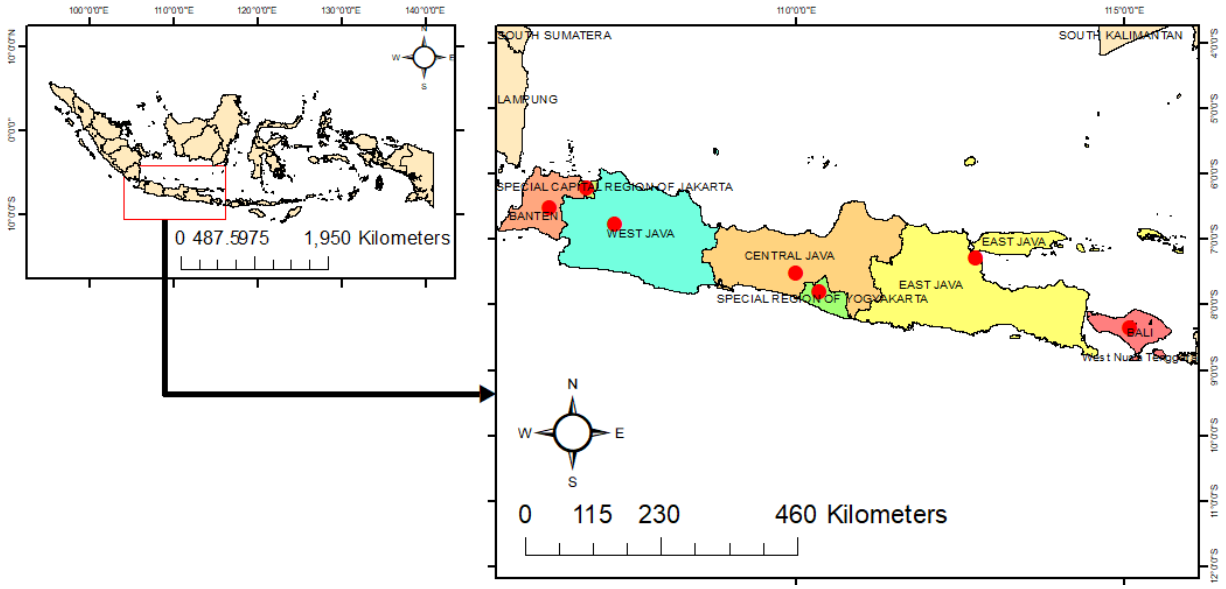

Figure 1 Study area of the ethnobotanical survey in 7 provinces in Indonesia

Data Collection

A cross-sectional study was undertaken using a self-administered and structured questionnaire. The questionnaire consisted of three parts that aimed to collect the respondents demographic characteristics, medicinal plants data, and respondents' motivation using the plants during the pandemic. The data collection was carried out by online survey from June to August 2020. The questionnaire was in Indonesian and examined by two experts in pharmacy and Bahasa Indonesia fields then piloted among 30 participants to ensure its validity before being used to collect data. A guide to estimate the minimum sample size of respondents required for this study based on the formula (Pourhoseingholi *et al.* 2013).

$$n = \frac{z^2 p(1-p)}{d^2}$$

Where:

Z = The statistic corresponding to level of confidence.

P = Expected prevalence of COVID-19.

d = Precision.

In this study, the respondents included indigenous people living in Java and Bali islands and consuming medicinal plants during the COVID-19 pandemic in Indonesia. The respondents' motivation to use the plants was also recorded. Any dubious data that could not be confirmed was excluded. The questionnaire and methodology for this study were approved by the Faculty of Medicine, Udayana University (Ethics approval number: 1195/UN14.2.2.VII.14/LT/2020).

Plant Identification

The scientific names of medicinal plants reported by respondents were determined using cross-references between their local names and database in Indonesian Herbal Pharmacopeia, Indonesian Herbal Formulary (PERMENKES NO.6/2016), and Indonesian Traditional Medicine Formulary (HK.01.07/MENKES/ 187/2017). Herbal specimens could not be collected due to the strict travel restrictions regulated by the Indonesian government during the COVID-19 pandemic in the study area. The scientific names of the reported plants were checked with The Plant List website (accessed on January 8, 2021, http://www.theplantlist.org).

Data Analysis

The collected data were evaluated by using Microsoft Office Excel (2016) spreadsheets. Further, quantitative data analysis to show the local importance of each plant species was demonstrated by using the relative frequency of citation (RFC) (Aziz *et al.* 2017). with the formula below:

$$RFC = FC/N \ (0 < RFC < 1)$$

Where:

FC = Number of informants mentioning a particular species.

N = Total number of respondents

RESULTS AND DISCUSSION

Indonesia is an inhabitant of about 80% of the world's medicinal plants which local people use to prevent and cure many ailments (Elfahmi *et al.* 2014). In the current study, an online survey was conducted to collect data regarding medicinal plant usage by Indonesian during the COVID-19 pandemic. The respondents were limited to those who were native and living in 8 provinces in the two most densely populated islands in Indonesia (Java and Bali islands) (Table 1). Moreover, based on the Indonesian government's official website (www.covid19.go.id), most of the confirmed COVID-19 cases were located in both islands and the prevalence reached 82.2%. Based on the prevalence of COVID-19 and the statistic corresponding to the level of confidence is 1,96 with a precision of 5%, the minimum number of respondents for this study was 224 respondents. However, in this study, 344 respondents participated and this number exceeded the minimum sample.

As shown in Table 1, 82.04% (274) of respondents were female. This result is in line with several studies (Villena-Tejada *et al.* 2021; Brahmi *et al.* 2022; Odebunmi *et al.* 2022). Which indicated the domination of females in using medicinal plants. This predominance is probably related to several factors such as women being more familiar with medicinal plants because they

are also being used as cooking ingredients. Correspondingly, in most populations, women are believed to bear the responsibility for the family health needs causing them to be more informed about using medicinal plants than their male counterparts (Torres-Avilez *et al.* 2016). In the current study, most of the respondents came from the Province of Bali. A Hindu-most populated area in Indonesia (Statistics Indonesia 2010). The Balinese are well known for their local wisdom called Usada, a traditional medicine inspired by the Hindu holy book Ayurveda (Muderawan *et al.* 2020). Age is another sociodemographic factor contributing to the use of medicinal plants. Several studies found that older age was the main user of traditional medicine (Rahayu *et al.* 2020). On the contrary, 67.37% (225) of respondents in this study were 20 to 40 years old. Indicating the younger age group was also interested in using medicinal plants during the pandemic of COVID-19. Similar survey studies conducted in Algeria and Morocco during the pandemic also showed similiar results (Belmouhoub *et al.* 2021; Brahmi *et al.* 2022; Chebaibi *et al.* 2022).

Table 1 Demographic characteristics of respondents

Characteristic	Number of Respondents (n = 334)	Percentage (%)
Gender		
Male	60	17.96
Female	274	82.04
Province of Origin		
Special Capital Region of Jakarta	13	3.89
Banten	2	0.60
West Java	35	10.48
Central Java	8	2.40
East Java	24	7.19
Special Region of Yogyakarta	6	1.80
Bali	246	73.65
Age (years)		
< 20	35	10.48
20 – 40	225	67.37
> 40	74	22.16
Religion		
Islam	66	19.76
Hindu	247	73.95
Protestant	12	3.59
Catholic	8	2.40
Buddha	1	0.30

Table 2 Medicinal plants used by respondents during the COVID-19 pandemic in Indonesia

Family	Scientific Names	Local Names (Indonesia)	Common Names (English)	Part used	Method of Preparation[a]	RFC[b]	Motivation of use[c]	Reported from[d]
Acanthaceae	*Andrographis paniculata* (Burm.f.) Nees	*Sambiloto*	Green chiretta	Leaves	Boil	0.030	A, B, D, E	1, 5, 7
Amaryllidaceae	*Allium cepa* L.	*Bawang merah*	Shallot	Bulb	Boil, burning, eaten directly	0.006	B	6,7
	Allium sativum L.	*Bawang putih*	Garlic	Bulb	Eaten directly	0.063	A-E	3-7
Anacardiaceae	*Spondias pinnata* (L.f) Kurz.	*Cemcem*	Common hog-plum	Leaves	Cold infusion	0.006	B	7
Annonaceae	*Annona muricata* L.	*Sirsak*	Soursop	Leaves	Boil	0.015	A-D	3,7
Apiaceae	*Apium graveolens* L.	*Seledri*	Celery	Leaves	Boil	0.003	B	3
	Centella asiatica (L.) Urb.	*Pegagan*	Asiatic pennywort	Leaves	Boil, eaten directly	0.021	A,B,D,E	7
	Coriandrum sativum L.	*Ketumbar*	Coriander	Fruit	Boil	0.012	A,B,D,E	3, 5, 7
	Foeniculum vulgare	*Adas*	Fennel	Fruit	Boil	0.003	B	4

Family	Scientific Names	Local Names (Indonesia)	Common Names (English)	Part used	Method of Preparation[a]	RFC[b]	Motivation of use[c]	Reported from[d]
	Mill.							
Arecaceae	*Cocos nucifera* L.	*Kelapa*	Coconut	Fruit (water & oil)	Eaten directly	0.009	B	7
Asteraceae	*Blumea balsamifera* (L.) DC.	*Sembung*	Buffalo-ear	Leaves	Boil	0.006	B,D	7
	Gynura procumbens (Lour.) Merr.	*Sambung nyawa*	Longevity spinach	Leaves	Boil	0.003	B	6
	Pluchea indica (L.) Less.	*Beluntas*	Indian camphorweed	Leaves	Boil	0.009	B	7
	Sonchus arvensis L.	*Tempuyung*	Perennial Sow-thistle	Leaves	Boil	0.003	B	7
Basellaceae	*Anredera cordifolia* (Ten.) Steenis	*Binahong*	Gulf madeiravine	Leaves	Boil	0.003	B	1
Caricaceae	*Carica papaya* L.	*Pepaya*	Papaya	Leaves	Boil	0.003	E	3
Fabaceae	*Caesalpinia sappan* L.	*Secang*	Brazilwood	Wood	Boil	0.027	A-E	3-7
	Clitoria ternatea L.	*Bunga telang*	Asian pigeonwings	Flower	Boil	0.009	A,D	5, 7
	Erythrina variegata L.	*Dadap*	Tiger's claw	Leaves	Boil	0.003	A,D	7
	Tamarindus indica L.	*Asam jawa*	Tamarind	Fruit	Boil	0.060	A-E	1, 3-7
Lamiaceae	*Mentha piperita* L.	*Pipermin*	Peppermint	Leaves	Hot infusion	0.009	A,B,D,E	2, 3, 7
	Peronema canescens Jack	*Sungkai*	False elder	Leaves	Boil	0.003	B	3
Lauraceae	*Cinnamomum burmanni* (Nees & T.Nees) Blume	*Kayu manis*	Batavia cinnamon	Bark, Leaves	Boil, burning, cold and hot infusion	0.114	A-E	1-7
Malvaceae	*Hibiscus sabdariffa* L.	*Rosela*	Roselle	Flower	Boil	0.003	B	7
Meliaceae	*Azadirachta indica* A.Juss	*Mimba*	Neem	Leaves	Eaten directly	0.003	B	7
Moraceae	*Artocarpus altilis* (Parkinson ex F.A.Zorn) Fosberg	*Sukun*	Breadfruit	Leaves	Boil	0.003	B	7
Moringaceae	*Moringa oleifera* Lam.	*Kelor*	Drumstick tree	Leaves	Boil, hot infusion	0.045	A-E	3-7
Myrtaceae	*Melaleuca cajuputi* Powell	*Kayu putih*	Cajuput	Oil	N/A	0.003	C	1,7
	Syzygium aromaticum (L.) Merr. & L.M.Perry	*Cengkeh*	Clove	Flower	Boil, hot infusion	0.048	A-E	2-7
	Syzygium polyanthum (Wight) Walp.	*Salam*	Indonesian bay leaf	Leaves	Boil	0.021	A-E	3, 5-7
Oleaceae	*Olea europaea* L.	*Zaitun*	Olive	Fruit (Oil)	Eaten directly	0.003	B	3
Pandanaceae	*Pandanus amaryllifolius* Roxb.	*Pandan*	Pandan	Leaves	Boil	0.003	A,D	2
Phyllanthaceae	*Sauropus androgynous* (L.) Merr.	*Katuk*	Sweet leaf	Leaves	Cold and hot infusion	0.021	A,B,D,E	7
	Phyllantus niruri L.	*Meniran*	Gale of the wind	Leaves	Boil, hot infusion	0.009	A,B	5, 7
Piperaceae	*Piper betle* L.	*Sirih*	Betel	Leaves	Boil, eaten directly	0.072	A-E	1, 3
	Piper crocatum Ruiz & Pav.	*Sirih merah*	Celebes pepper	Leaves	Boil	0.072	B	7
	Piper nigrum L.	*Lada*	Black pepper	Seed	Boil	0.003	B	3
	Piper retrofractum Vahl	*Cabai jawa*	Javanese long pepper	Fruit	Boil	0.003	E	7
Poaceae	*Cymbopogon citratus* (DC.) Stapf.	*Serai dapur*	Lemongrass	Stem, Leaves	Boil, hot infusion	0.269	A-E	1-7
	Oryza sativa L.	*Beras*	Rice	Starch	Cold infusion	0.024	A,B,D,E	3-7
Ranunculaceae	*Nigella sativa* L.	*Jintan hitam*	Black seed	Seed	Boil	0.012	A,B,E	3, 5, 7
Rutaceae	*Citrus aurantiifolia* (Christm.) Swingle	*Jeruk nipis*	Egyptian lime	Fruit	Juiced, boil, hot and cold infusion	0.177	A-E	1-7
	Citrus hystrix DC.	*Jeruk purut*	Kaffir lime	Leaves, Fruit	Boil	0.006	B,E	6
	Citrus limon (L.) Osbeck	*Lemon*	Lemon	Fruit	Cold and hot infusion	0.108	A-E	1, 3-5, 7
	Citrus reticulata	*Jeruk*	Mandarin	Fruit	Eaten directly	0.021	A,B,E	4, 7

Family	Scientific Names	Local Names (Indonesia)	Common Names (English)	Part used	Method of Preparation[a]	RFC[b]	Motivation of use[c]	Reported from[d]
	Blanco							
Rubiaceae	*Morinda citrifolia* L.	*Mengkudu*	Noni	Fruit	Juiced	0.015	B-D	7
Schisandraceae	*Illicium verum* Hook.f.	*Bunga lawang*	Star anise	Flower	Boil	0.009	A,B,E	4, 5, 7
Theaceae	*Camellia sinensis* (L) Kuntze	*Teh*	Tea plant	Leaves	Boil, hot infusion	0.012	B-D	1, 3, 7
Zingiberaceae	*Alpinia galanga* (L) Willd.	*Lengkuas*	Greater galangal	Rhizome	Boil, hot infusion	0.054	A-E	1, 4, 5, 7
	Boesenbergia pandurata (Roxb.) Schltr.	*Temu kunci*	Chinese keys	Rhizome	Boil	0.006	B,E	7
	Curcuma longa L.	*Kunyit*	Turmeric	Rhizome	Boil, burning, hot infusion	0.707	A-E	1-7
	Curcuma zanthorrhiza Roxb.	*Temulawak*	Javanese turmeric	Rhizome	Boil, hot infusion	0.165	A-E	1-7
	Curcuma zedoaria (Christm.) Roscoe	*Temu putih*	Zedoary	Rhizome	Boil	0.006	A,D,E	5, 7
	Amomum compactum Sol. ex Maton	*Kapulaga*	Javanese cardamom	Seed, flower	Boil, hot infusion	0.018	B,D,E	3, 5, 7
	Kaempferia galanga L.	*Kencur*	Cutcherry	Rhizome	Boil, burning, hot infusion	0.174	A-E	1-7
	Kaempferia rotunda L.	*Kunyit putih*	Peacock ginger	Rhizome	Juice, hot infusion	0.021	A,B,D,E	5, 7
	Zingiber officinale Roscoe	*Jahe*	Ginger	Rhizome	Boil, burning, hot infusion	0.674	A-E	1-7
	Zingiber officinale var.rubrum Theilade	*Jahe merah*	Red ginger	Rhizome	Boil, hot infusion	0.039	A,B,D,E	3, 5-7
	Zingiber zerumbet (L.) Roscoe ex Sm.	*Gamongan / lempuyang gajah*	Bitter ginger	Rhizome	Boil	0.003	E	7

Notes: [a]All plants were prepared with water and administered orally, except cajuput by inhalation.
[b]RFC = Relative Frequency of Citation,
[c]A = to keep healthy, B = to boost the immune system, C = to avoid virus infection, including COVID-19, D = to build stamina, E = other,
[d]1 = Special Capital Region of Jakarta, 2 = Banten, 3 = West Java, 4 = Central Java, 5 = East Java, 6 = Special Region of Yogyakarta, 7 = Bali, N/A = not available,

Table 3 Plants mixtures used by respondents during the COVID-19 pandemic in Indonesia

Plants	Mixture No.																														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
A. sativum	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. asiatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. nucifera	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. indica	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T. indica	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-
C. burmanni	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
S. aromaticum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
P. amaryllifolius	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. betle	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
C. citratus	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	+	+	-	+	+	-
O. sativa	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. aurantiifolia	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	-	+	-	+	-	+	-	-	+	-	-	-	-	-	+	-
C. lemon	+	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-
C. sinensis	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. galangal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
C. longa	-	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	-	-	-	+	+	+	+	+
C. zanthorrhiza	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-		-	-	-	+	+	-	-	-	-	-	-	+	+	-	+
K. galangal	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
K. rotunda	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Z. officinale	-	+	-	-	-	-	-	+	-	+	+	-	-	-	-	-	+	+	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+
Total plants mixed	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4	4	4

Notes: + = plants available in mixtures. * All mixtures were prepared by boiling and administered orally

Table 3 Plants mixture used by respondents during the COVID-19 pandemic in Indonesia (continued)

Plants	Mixture No.*																													
	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
C. asiatica	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
C. sativum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
F. vulgare	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
C. sappan	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	+	-	-	+	+	-
C. ternatea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
T. indica	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-
M. Piperita	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-
P. canescens	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C. burmanni	-	-	-	-	-	-	+	-	+	+	-	-	-	+	-	-	-	-	-	+	-	-	+	+	-	+	+	-	+	-
A. altilis	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. aromaticum	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	+	-	+	-	-	-	+	+	-	+	-
S. polyanthum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
O. europea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. amaryllifolius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
S. androgynous	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. niruri	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
P. betle	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+
P. crocatum	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
P. retrofractum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
C. citratus	-	-	-	-	+	+	-	-	-	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
C. aurantiifolia	-	+	+	-	+	-	-	-	-	-	-	-	-	-	+	-		-	-	-	-	-	-	+	+	-	-	-	+	-
C. lemon	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-
I. verum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	+	-
A. Galanga	+	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-
B. pandurate	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
C. longa	+	+	+	+	+	+	+	+	+	-	-	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+
C. zanthorrhiza	-	-	-	-	-	-	-	+	-	-	+	-	+	-	-	+	-	+	-	-	+	+	+	-	-	+	-	+	-	+
C. zedoaria	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A. compactum	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
K. galangal	+	+	+	+	-	+	-	+	+	-	-	-	-	-	-	-	-	-	+	+	+	+	-	-	-	-	+	+	+	+
K. rotunda	-	-	-		-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	+
Z. officinale	+	+	+	+	+	+	+	+	-	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Z. officinal var. *rubrum*	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Z. zerumbet	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
Total plants mixed	4	4	4	4	4	4	4	4	4	4	4	5	5	5	5	5	5	5	6	6	6	6	6	6	7	7	7	8	9	10

Notes: + = plants available in mixtures. * All mixtures were prepared by boiling and administered orally

Table 4 Method of preparation for medicinal plants used during the COVID-19 pandemic in Indonesia

Category	Frequency	%*
Boil	46	77.97
Eaten directly	6	10.17
Cold Infusion	18	30.51
Hot Infusion	8	13.56
Burning	5	6.78

Notes: *some of the plants were prepared by more than one method. Thus, the total percentage may not add up to 100%.

Table 5 The motivation for medicinal plants used by respondents during the COVID-19 pandemic in Indonesia

Category	Frequency	%*
to boost the immune system	238	71.26
to keep healthy	83	24.85
to build stamina	41	12.28
other motives	41	12.28
to prevent virus infection, including COVID-19	18	5.39

Notes: *some respondents reported more than one reason for herbal use. Thus, the total percentage may not add up to 100%.

The present study revealed that respondents used 59 species of medicinal plants from 28 families (Table 2) both singly or in herbal mixtures (Table 3). Additionally, most of the plants were prepared by boiling and then consumed orally (Table 4). Indonesian traditional medicine in the form of polyherbal drinks has existed for generations so called *loloh* (in Bali) and *jamu* (in Java). Some of the reported plants in the present study that are also used in *loloh* formulation namely *S. pinnata*, *B. balsamifera*, *E. variegata*., *C. burmanni*, *C. asiatica*, *A. indica*, *P. amaryllifolius*, *P. niruri*, *S. androgynous*, *P. betle*, *C. aurantiifolia*, *C. zanthorrhiza*, *K. rotunda*, *Z. officinale*, and *Z. zerumbet* (Sujarwo *et al.* 2015). Similarly, other reported plants were commonly available in *jamu* formula such as *C. verum*, *C. aurantifolia*, *Z. officinale* var. *Rubrum*, *T. indica*, *A. galanga*, *C. longa, C. zanthorrhiza*, *P. niruri*. *K. galanga*, *O. sativa*, and *P. amaryllifolius* (Elfahmi *et al.* 2014; Hartanti *et al.* 2020). These plants were empirically used for various medicinal purposes (Elfahmi *et al.* 2014; Sujarwo *et al.* 2015). Further, the current study revealed that respondents consumed *Jamu Kunyit Asam* and *Jamu Beras Kencur* during the pandemic (Table 3, Mixture No. 5 and No. 9, respectively). The composition of herbal mixtures could be varied according to individual preferences and local recipes. For example, Mixture No.20, 29, 45, 52, and 59 in Table 3 showed the variation of *Jamu Kunyit Asam*. However, there was limited data related to the efficacy of the modified version of *jamu* formula. Further research should be conducted to support the use of those herbal mixtures in term of efficacy test.

Most respondents believed that the plants' consumption was beneficial during the pandemic because they could enhance immunity, maintain health and stamina, and prevent viral infection (Table 5). A study showed that the interest in and use of immune-related herbals worldwide increased during the COVID-19 pandemic (Hamulka *et al.* 2020). Other ethnopharmacological studies confirmed the usage of medicinal plants such as *A. cepa*, *A. sativum*, *C. asiatica, C. papaya*, *T. indica*, *C. burmanni*, and *C. longa* to boost immunity by traditional healers and society in various health conditions (Siew *et al.* 2014; Anywar *et al.* 2020; Oladele *et al.* 2020; Lin *et al.* 2021). Meanwhile, review studies confirmed the benefit of natural immune enhancer intakes such as *A.* panniculata, *A. sativum*, *M. piperita*, *M. cajuputi* essential oil, *C.* sinensis, *N.* sativa, and *Z. officinale* to prevent COVID-19 and improve overall patient health (Boozari & Hosseinzadeh 2020; Sen *et al.* 2020; Silveira *et al.* 2020).

Some of the medicinal plants reported in the current study have been also recommended by the Indonesian Ministry of Health (HK.02.02/IV.2243/2020) to maintain well-being and prevent illness during the pandemic. In the official announcement, six herbal mixtures consisting of *Z. officinale* var. *rubrum*, *C. aurantiifolia*, *C. verum*, *C. longa*, *A. galanga*, *C. asiatica*, *C. zanthorrhiza*, *K. galanga*, *P. amaryllifolius*, *M. oleifera*, and *A. sativum*. The mixtures were recommended to boost the immune response and also have similar preparation and administration methods as reported in this study. Likewise, *C. longa*, *Z. officinalle*, *C.* verum, and *P. nigrum* also have been recommended by the Indian Ministry of AYUSH (Ayurveda, Yoga, and Naturopathy, Unani, Siddha, and Homeopathy) to boost immunity as a prophylaxis measure against COVID-19 (Khanal *et al.* 2020).

The beneficial effect of medicinal plants as immune-enhancer against COVID-19 should be confirmed scientifically. In viral diseases, the infection could be fought by the host's immune response. When viruses infect the host cells, innate immunity blocks virus replication, promotes virus clearance, stimulates tissue repair, and activates a prolonged adaptive immunity (G. Li *et al.* 2020). Moreover, viral infection and inflammation of lung tissues are observed in COVID-19. Thus, the antiviral and inflammatory activities of medicinal plants are essential properties to combat COVID-19 (Khanal *et al.* 2020). On the other hand, it should be noticed that the immune system is complicated and highly regulated by numerous molecular and cellular events. Therefore, immunity enhancement may be either valuable or destructive to the organism, depending on the overall degree of modulation and the pathophysiological condition (Gertsch *et al.* 2011).

Based on the calculation of RFC, five plants had the highest scores: *C. longa*, *Z. officinale*, *C.*

citratus, *K. galanga*, and *C. zanthorrhiza*. Therefore, further literature review in the current study was highlighted for those plants. Turmeric (*C. longa*) contains curcumin, a polyphenol with various pharmacological actions. The compound showed immunomodulation activity through several mechanisms, especially by regulating inflammatory factors (Tasneem *et al.* 2019; Behl *et al.* 2021). Likewise, the polysaccharide extract from turmeric could enhance the immune system (Yue *et al.* 2010). A computational study regarding anti-SARS-CoV-2 showed that curcumin exhibited a high potency to block the virus's main protease ($C19M^{pro}$), which plays an important role in the viral replication process. Curcumin had lower binding energy to $C19M^{pro}$ than other compounds from *P. nigrum*, *Z. officinale*, *N. sativa*, *S. aromaticum*, *A. sativum* and *A. cepa* (Ibrahim *et al.* 2020).

Ginger (*Z. officinale*) contains some compounds with anti-inflammatory and immunomodulatory activities such as 6-gingerol, 6-shogaol, zingerone, and 6-paradol (Choi *et al.* 2018). An alcohol extract was reported to induce phagocytosis by macrophages in mice while crude extract increased humoral and cell-mediated immune responses (Gautam *et al.* 2020). Meanwhile, another molecular docking evaluation showed the ability of zingiberene, 6-gingerol, zingerone, gingerenone-A, 6-shogaol, and 6-dehydrogingerdione to block $C19M^{pro}$. But their potencies were considerably low due to higher binding energies than N3 inhibitor as control (Garg *et al.* 2020).

An *in vivo* and *in vitro* study revealed the immunomodulatory effect of water extract and essential oil from lemongrass (*C. citratus*). The water extract with linalool oxide and epoxy-linalool as major compounds could prevent the production of IL-1β but induce IL-6 production by macrophages. Meanwhile, its essential oils which contained neral and geranial could inhibit cytokine production *in vitro* (Sforcin *et al.* 2009). Moreover, geraniol, another compound in its essential oil, inhibited the S1 subunit in spike proteins of SARS-CoV-2 through a docking simulation (Wani *et al.* 2020).

The rhizome part of cutcherry (*K. galanga*) is rich in bioactive compounds such as ethyl-p-methoxycinnamate and diarylheptanoids with anti-inflammatory and immunomodulation activity (Jagadish *et al.* 2016; Yao *et al.* 2018). Its polysaccharides isolate enhanced the immunoregulation capability of CD4+ T cells (Yang *et al.* 2018). Furthermore, a computational study exhibited the activity of its bioactive compounds (kaempferol, kaempferol glycosides, and acylated kaempferol glucoside derivatives) to block the 3a channel protein of SARS-CoV. Inhibition of this channel would inactivate virus production and allow the host to build up its immunity system (Schwarz *et al.* 2014). Another docking investigation indicated that kaempferol, due to its hydroxyl, ketone, and ether groups, was a stronger $C19M^{pro}$ inhibitor than other tested natural compounds (Khaerunnisa *et al.* 2020).

The crude polysaccharide extract of Javanese turmeric (*C. zanthorrhiza*) could enhance the immune system by activating of NF-kappaB (Kim *et al.* 2007). Xanthorrhizol and *C. xanthorrhiza* extract significantly inhibited the production of inflammatory cytokines, such as tumor necrosis factor-alpha, interleukin-6 and -1β, and C-reactive protein (Kim *et al.* 2014). Moreover, curcumin, demethoxycurcumin, and bisdemethoxycurcumin in *C. xanthorrhiza* (similar compounds also contained in *C. longa*) showed their potential as $C19M^{pro}$ inhibitors (Khaerunnisa *et al.* 2020; Sumaryada & Pramudita 2020). However, another study revealed that their inhibition actions were lower than nelfinavir, a protease inhibitor used as a drug standard (Khaerunnisa *et al.* 2020). Meanwhile, another docking investigation on the similarity of active sites exposed that bisdemethoxycurcumin had a greater ability to inhibit the binding pocket of $C19M^{pro}$ than N3 inhibitor, as the control ligand (Sumaryada & Pramudita 2020).

Other plants with lower RFC values (Table 2) such as *A. galanga* and *A. paniculata, Citrus sp.*, *C. sinensis*, *S. androgynous*, *F. vulgare*, *O. europea*, and *A. graveolens* also confirmed to have immunomodulatory properties and potential against COVID-19 (Elfahmi *et al.* 2014; Khaerunnisa *et al.* 2020; Utomo *et al.* 2020). Regarding COVID-19, most of the antiviral studies of medicinal plants and their compounds were based on computational methods and resulted in a preview of their potential against COVID-19. Though some of the reported medicinal plants showed low molecular potency in blocking target sites, it is necessary to

highlight that the immunomodulatory actions support their beneficial role during the COVID-19 pandemic. Further pre-clinical and clinical investigations are needed to warrant their efficacy as health-promoting agents against COVID-19. These ethnobotany research results may be necessary to anticipate another trans-boundary animal or plant diseases pandemic by studying their bioactive compound for pharmacopeia studies in more detail.

CONCLUSION

During the COVID-19 pandemic, there were 59 medicinal plants belonging to 28 families used by Indonesian. The plants were prepared mainly by boiling and administered orally. Based on the RFC value, the most important plants were *C. longa*, *Z. officinale*, *C. citratus*, *K. galanga*, and *C. zanthorrhiza*. Also, respondents believed that those plants could boost immunity, maintain health and stamina, and prevent COVID-19. In general, the medicinal plants reported in the current studies were confirmed by scientific literature to be beneficial as immune-booster during the COVID-19 pandemic. Meanwhile, their ability to block SARS-CoV-2 infection was mainly studied only through molecular docking evaluations. More research should be conducted to ensure their potency against SARS-CoV-2 and their efficacy when used as a single ingredient or in mixtures with other herbs. Also, actions should be taken to preserve the community's traditional knowledge of using medicinal plants.

ACKNOWLEDGMENTS

The authors are grateful to the authorities of the Faculty of Pharmacy, Universitas Mahasaraswati Denpasar and Indonesia Government, through the Directorate General of Politics and Public Administration, Ministry of Home Affairs (NO/460.02/350/DV) for approving this study

REFERENCES

Anywar G, Kakudidi E, Byamukama R, Mukonzo J, Schubert A, Oryem-Origa H. 2020. Medicinal plants used by traditional medicine practitioners to boost the immune system in people living with HIV/AIDS in Uganda. Eur J Integr Med. 35:101011.

Aziz MA, Khan AH, Adnan M, Izatullah I. 2017. Traditional uses of medicinal plants reported by the indigenous communities and local herbal practitioners of Bajaur Agency, Federally Administrated Tribal Areas, Pakistan. J Ethnopharmacol. 198: 268-281.

Behl T, Kumar K, Brisc C, Rus M, Nistor-Cseppento DC, Bustea C, Aron RAC, Pantis C, Zengin G, Sehgal A, et al. 2021. Exploring the multifocal role of phytochemicals as immunomodulators. Biomed Pharmacother. 133: 110959.

Belmouhoub M, Aberkane B, Bey MB. 2021. Ethnopharmacological survey on medicinal plants used by Algerian population to prevent SARS-CoV-2 infection. Ethnobot Res Appl. 22: 1-13.

Boozari M, Hosseinzadeh H. 2020. Natural products for COVID-19 prevention and treatment regarding to previous coronavirus infections and novel studies. Phyther Res. 35(2): 864-876.

Brahmi F, Iblhoulen Y, Issaadi H, Elsebai MF, Madani K, Boulekbache-Makhlouf L. 2022. Ethnobotanical survey of medicinal plants of bejaia localities from algeria to prevent and treat coronavirus (COVID-19) infection shortened title: phytomedicine to manage COVID-19 pandemic. Adv Tradit Med.: 1-13.

Chebaibi M, Bousta D, Bourhia M, Baammi S, Salamatullah AM, Nafidi HA, Hoummani H, Achour S. 2022. Ethnobotanical study of medicinal plants used against COVID-19. Evidence-based Complement Altern Med. 2022: 2085297.

Choi JG, Kim SY, Jeong M, Oh MS. 2018. Pharmacotherapeutic potential of ginger and its compounds in age-related neurological disorders. Pharmacol Ther. 182: 56-69.

Djalante R, Lassa J, Setiamarga D, Sudjatma A, Indrawan M, Haryanto B, Mahfud C, Sinapoy MS, Djalante S, Rafliana I, et al. 2020. Review and analysis of current responses to COVID-19 in Indonesia: Period of January to March 2020. Prog Disaster Sci. 6: 100091.

Elfahmi, Woerdenbag HJ, Kayser O. 2014. Jamu: Indonesian traditional herbal medicine towards rational phytopharmacological use. J Herb Med. 4(2): 51-73.

Garg S, Anand A, Lamba Y, Roy A. 2020. Molecular docking analysis of selected phytochemicals against SARS-CoV-2 Mpro receptor. Vegetos. 33(4): 766-781.

Gautam S, Gautam A, Chhetri S, Bhattarai U. 2020. Immunity against COVID-19: Potential role of Ayush Kwath. J Ayurveda Integr Med.

13(1):100350.

Gertsch J, Viveros-Paredes JM, Taylor P. 2011. Plant immunostimulants - Scientific paradigm or myth? J Ethnopharmacol. 136(3): 385-391.

Ghaffari S, Roshanravan N, Tutunchi H, Ostadrahimi A, Pouraghaei M, Kafil B. 2020. Oleoylethanolamide, A bioactive lipid amide, as a promising treatment strategy for Coronavirus/COVID-19. Arch Med Res. 51(5): 464-467.

Hamulka J, Jeruszka-Bielak M, Górnicka M, Drywień ME, Zielinska-Pukos MA. 2020. Dietary supplements during COVID-19 outbreak. Results of Google Trends Analysis supported by PLifeCOVID-19 online studies. Nutrients. 13(1): 54.

Hartanti D, Dhiani A, Lintang Charisma S, Wahyuningrum R. 2020. The Potential Roles of Jamu for COVID-19: A Learn from the Traditional Chinese Medicine. Pharm Sci Res. 7: 12-22.

Ibrahim MAA, Abdelrahman AHM, Hussien TA, Badr EAA, Mohamed TA, El-Seedi HR, Pare PW, Efferth T, Hegazy MEF. 2020. In silico drug discovery of major metabolites from spices as SARS-CoV-2 main protease inhibitors. Comput Biol Med. 126: 104046.

Jadid N, Kurniawan E, Himayani CES, Andriyani, Prasetyowati I, Purwani KI, Muslihatin W, Hidayati D, Tjahjaningrum ITD. 2020. An ethnobotanical study of medicinal plants used by the Tengger tribe in Ngadisari village, Indonesia. Ahmad KS, editor. PLoS One. 15(7): e0235886.

Jagadish PC, Latha KP, Mudgal J, Nampurath GK. 2016. Extraction, characterization and evaluation of Kaempferia galanga L. (Zingiberaceae) rhizome extracts against acute and chronic inflammation in rats. J Ethnopharmacol. 194: 434-439.

Khaerunnisa S, Kurniawan H, Awaluddin R, Suhartati S, Soetjipto S. 2020 Mar. Potential inhibitor of COVID-19 main protease (Mpro) from several medicinal plant compounds by molecular docking study. Preprint.

Khanal P, Duyu T, Patil BM, Dey YN, Pasha I, Wanjari M, Gurav SS, Maity A. 2020. Network pharmacology of AYUSH recommended immune-boosting medicinal plants against COVID-19. J Ayurveda Integr Med. 13(1): 100374.

Khanna K, Kohli SK, Kaur R, Bhardwaj A, Bhardwaj V, Ohri P, Sharma A, Ahmad A, Bhardwaj R, Ahmad P. 2020. Herbal immune-boosters: Substantial warriors of pandemic Covid-19 battle. Phytomedicine. 85: 153361.

Kim AJ, Kim YO, Shim JS, Hwang JK. 2007. Immunostimulating activity of crude polysaccharide extract isolated from Curcuma xanthorrhiza Roxb. Biosci Biotechnol Biochem. 71(6): 1428-1438.

Kim MB, Kim C, Song Y, Hwang JK. 2014. Antihyperglycemic and anti-inflammatory effects of standardized Curcuma xanthorrhiza Roxb. extract and its active compound xanthorrhizol in high-fat diet-induced obese mice. Evidence-based Complement Altern Med. 2014: 205915.

Li G, Fan Y, Lai Y, Han T, Li Z, Zhou P, Pan P, Wang W, Hu D, Liu X, et al. 2020. Coronavirus infections and immune responses. J Med Virol. 92(4): 424-432.

Li Y, Liu X, Guo L, Li J, Zhong D, Zhang Y, Clarke M, Jin R. 2020. Traditional Chinese herbal medicine for treating novel coronavirus (COVID-19) pneumonia: Protocol for a systematic review and meta-Analysis. Syst Rev. 9(1): 1-6.

Lin LT, Hsu WC, Lin CC. 2014. Antiviral natural products and herbal medicines. J Tradit Complement Med. 4(1): 24-35.

Lin Y, Wang S ping, Zhang J yu, Zhuo Z yuan, Li Xin rou, Zhai C jia, Li Xiao xue, Qi F hua, Ding X, Chen C yun, et al. 2021. Ethnobotanical survey of medicinal plants in Gaomi, China. J Ethnopharmacol. 265: 113228.

Muderawan IM, Budiawan IM, Giri MKW, Atmaja INB. 2020. Usada: The Ethnomedicine of Balinese Society. Int J Ayurvedic Herb Med. 10(6): 3893-3905.

Nahdi MS, Kurniawan AP. 2019. The diversity and ethnobotanical study of medicinal plants in the southern slope of Mount Merapi, Yogyakarta, Indonesia. Biodiversitas. 20(8): 2279-2287.

Odebunmi CA, Adetunji TL, Adetunji AE, Olatunde A, Oluwole OE, Adewale IA, Ejiwumi AO, Iheme CE, Aremu TO. 2022. Ethnobotanical survey of medicinal plants used in the treatment of COVID-19 and related respiratory infections in Ogbomosho South and North Local Government areas, Oyo State, Nigeria. Plants. 11(19): 2667.

Oladele JO, Ajayi EI, Oyeleke OM, Oladele OT, Olowookere BD, Adeniyi BM, Oyewole OI, Oladiji AT. 2020. A systematic review on COVID-19 pandemic with special emphasis on curative potentials of Nigeria based medicinal plants. Heliyon. 6(9): e04897.

Pourhoseingholi MA, Vahedi M, Rahimzadeh M. 2013. Sample size calculation in medical studies. Gastroenterol Hepatol from bed to bench. 6(1): 14-17.

Rahayu YYS, Araki T, Rosleine D. 2020. Factors affecting the use of herbal medicines in the universal health coverage system in Indonesia. J Ethnopharmacol. 260: 112974.

Schwarz S, Sauter D, Wang K, Zhang R, Sun B, Karioti A, Bilia AR, Efferth T, Schwarz W. 2014. Kaempferol derivatives as antiviral drugs against the 3a channel protein of coronavirus. Planta Med. 80(2-3): 177-182.

Sen D, Debnath P, Debnath B, Bhaumik S, Debnath S. 2020. Identification of potential inhibitors of SARS-CoV-2 main protease and spike receptor from 10 important spices through structure-based virtual screening and molecular dynamic study. J Biomol Struct Dyn. 40(2): 941-962.

Sforcin JM, Amaral JT, Fernandes A, Sousa JPB, Bastos JK. 2009. Lemongrass effects on IL-1β and IL-6 production by macrophages. Nat Prod Res. 23(12): 1151-1159.

Siew YY, Zareisedehizadeh S, Seetoh WG, Neo SY, Tan CH, Koh HL. 2014. Ethnobotanical survey of usage of fresh medicinal plants in Singapore. J Ethnopharmacol. 155(3): 1450-1466.

Silveira D, Prieto-Garcia JM, Boylan F, Estrada O, Fonseca-Bazzo YM, Jamal CM, Magalhães PO, Pereira EO, Tomczyk M, Heinrich M. 2020. COVID-19: Is there evidence for the use of herbal medicines as adjuvant symptomatic therapy? Front Pharmacol. 11: 581840.

Statistics Indonesia T. 2010. Badan Pusat Statistik Provinsi Bali. [cited 2023 May 29]. https://bali.bps.go.id/statictable/2023/05/19/189/penduduk-provinsi-bali-menurut-agama-yang-dianut-hasil-sensus-penduduk-1971-2000-dan-2010.html.

Sujarwo W, Keim AP, Savo V, Guarrera PM, Caneva G. 2015. Ethnobotanical study of Loloh: Traditional herbal drinks from Bali (Indonesia). J Ethnopharmacol. 169: 34-48.

Sumaryada T, Pramudita CA. 2020. Molecular docking evaluation of some Indonesian's popular herbals for a possible COVID-19 treatment. Biointerface Res. Appl. Chem. 11(3): 9827-9835.

Taek MM, Banilodu L, Neonbasu G, Watu YV, E.W. BP, Agil M. 2019. Ethnomedicine of Tetun ethnic people in West Timor Indonesia: philosophy and practice in the treatment of malaria. Integr Med Res. 8(3): 139-144.

Tasneem S, Liu B, Li B, Choudhary MI, Wang W. 2019. Molecular pharmacology of inflammation: Medicinal plants as anti-inflammatory agents. Pharmacol Res. 139: 126-140.

Torres-Avilez W, Medeiros PM De, Albuquerque UP. 2016. Effect of gender on the knowledge of medicinal plants: Systematic review and meta-analysis. Evidence-based Complement Altern Med. 2016:6592363.

Utomo RY, Ikawati M, Meiyanto E. 2020. Revealing the potency of Citrus and Galangal constituents to halt SARS-CoV-2 infection. Preprint.

Vellingiri B, Jayaramayya K, Iyer M, Narayanasamy A, Govindasamy V, Giridharan B, Ganesan S, Venugopal A, Venkatesan D, Ganesan H, et al. 2020. COVID-19: A promising cure for the global panic. Sci Total Environ. 725:138277.

Villena-Tejada M, Vera-Ferchau I, Cardona-Rivero A, Zamalloa-Cornejo R, Quispe-Florez M, Frisancho-Triveño Z, Abarca-Meléndez RC, Alvarez-Sucari SG, Mejia CR, Yañez JA. 2021. Use of medicinal plants for COVID-19 prevention and respiratory symptom treatment during the pandemic in Cusco, Peru: A cross-sectional survey. PLoS One. 16(9):e0257165.

Wani AR, Yadav K, Khursheed A, Rather MA. 2020. 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. Microb Pathog. 152:104620.

Yang X, Ji H, Feng Y, Yu J, Liu A. 2018. Structural characterization and antitumor activity of polysaccharides from Kaempferia galanga L. Oxid Med Cell Longev. 2018:9579262.

Yao F, Huang Y, Wang Y, He X. 2018. Anti-inflammatory diarylheptanoids and phenolics from the rhizomes of kencur (Kaempferia galanga L.). Ind Crops Prod. 125:454–461.

Yue GGL, Chan BCL, Hon PM, Kennelly EJ, Yeung SK, Cassileth BR, Fung KP, Leung PC, Lau CBS. 2010. Immunostimulatory activities of polysaccharide extract isolated from Curcuma longa. Int J Biol Macromol. 47(3):342–347.