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Brief survey on phytochemicals to prevent COVID-19

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ABSTRACT

Background: The recent pandemic by COVID-19 is a global threat to human health. The disease is caused by SARS-CoV-2 and the infection rate is increased more quickly than MERS and SARS as their rapid adaptation to varied climatic conditions through rapid mutations. It becomes more severe due to the lack of proper therapeutic drugs, insufficient diagnostic tool, scarcity of appropriate drug, life supporting medical facility and mostly lack of awareness. Therefore, preventive measure is one of the important strategies to control. In this context, herbal medicinal plants received a noticeable attention to treat COVID-19 in Indian subcontinent. Here, 44 Indian traditional plants have been discussed with their novel phytochemicals that prevent the novel corona virus. The basic of SARS-CoV-2, their common way of transmission including their effect on immune and nervous system have been discussed. We have analysed their mechanism of action against COVID-19 following in-silico analysis. Their probable mechanism and therapeutic approaches behind the activity of phytochemicals to stimulate immune response as well as inhibition of viral multiplication discussed rationally. Thus, mixtures of active secondary metabolites/phytochemicals are the only choice to prevent the disease in countries where vaccination will take long time due to overcrowded population density.

In this fearful situation, we may be dependent on herbal medicines for corona treatment. Various types of tribal people are living in several states of India including Jharkhand, Sikkim, Nagaland, and Karnataka etc. Most of the time people also depend upon local herbs for the treatment of any infectious diseases [4]. After the creation of the world, life was originated and at the same time the nature has created FLORA i.e., vegetation kingdom/plant kingdom. The animals including human also being dependent upon natural vegetation. Not only India, many countries of world partially depend upon the herbal product for their live hoods [5]. Even many herbal based companies have been developed in India like Patanjali, Himalaya, Dabour etc. several years ago [6]. According to the famous books ‘SUSHRUT SAMHITA’ and ‘CHARAK SAMHITA’ ancient people used the different parts of plants to cure themselves from several infectious disease [7]. The very special books were the pioneers or pathfinders and we owe to them in the modern age also. We can also refer ‘The Ramayana’ in regarding medicinal plant. It is also a common picture today that some carnivorous animals like dog, mongoose etc. eat...
The main ecosystem for proper existence of human beings, so, we need to follow save our planet from several epidemics and also biodiversity with air pollution for mainly isolation from tree. At that time if we want to inhibit replication of virus [21]. Beside synthetic drug, herbal treatment plays front line defence against COVID-19 infection in many developed countries even china [11].

Ubiquitously expressed that since antiquity Licorice is one of the most widely used medicinal plants [12]. The use of the herbal plants can be traced back from ancient Assyrian, Egyptian, Chinese and Indian cultures that was appreciated by ancient Greeks and Romans. From ancient time Licorice was used in Arabic medicine during the Middle Ages, as documented by the Canoneon Ibn Sina (980–1037 AD), a summary of Hippocrates and Galen’s medicine. This plant use in respiratory viral infections such as hoarse voice or dry cough and including hepatitis infection [Fiore et al., 2008]. Besides traditional use a few numbers of herbs specifically interact with surface protein or viral intracellular enzymes which can promote viral infection [13]. The chamomile plant called Anthemis hyalina inhibit replication of virus [14].

During globalization civilized human face global warming including air pollution for mainly isolation from tree. At that time if we want to save our planet from several epidemics and also biodiversity with ecosystem for proper existence of human beings, so, we need to follow the path of great, ancient Indian physician’s Charak and Sushrut during focus on the herbal medicines in our daily life [15]. The main objective of this study is to investigate the effects of phytochemicals against COVID-19.

2. Corona virus

CoVs have four genera in Coronavirinae subfamily such as A-CoV (Alpha-CoV), B–CoV (Beta-CoV), D-CoV (Delta-CoV) and G-CoV (Gamma-CoV) [16]. Crown shaped spike surrounded protein envelope that responsible for mainly respiratory diseases but few enteric diseases in many hosts like cat, human, rodent and pig etc. [17]. Different genotypic character containing Human CoV (HCoV) act on humans, those are included HCoV-OC43, HCoV-229E, Middle East Respiratory Syndrome CoV (MERS-CoV) and Severe Acute Respiratory Syndrome CoV (SARS-CoV) [18]. COVID-19 viruses have 27–32 kb non segmented (+) ssRNA, which has diameter about 60–160 nm and genome RNA modified by 3’-poly A tail and 5’-cap [19]. The genome of COVID-19 virus able to code four structural proteins and more non-structural proteins included mainly on two ORFs (ORF1a and ORF1b) that will ultimately be fragmented into about 16 proteins [20]. The non-structural proteins are involved modification of host immune system and they can participate the viral genome replication [21]. Envelope (E), Nucleocapsid (N), membrane (M) and spike (S) proteins are synthesis from 3’-end of ORF whereas 5’-end of ORF encode sixteen non-structural proteins (nsp1 to nsp16). The M, E, and S protein present mainly envelope of corona virus, those are responsible for viral assembly pathogenesis and invade of target cells [22].

3. Common therapy for COVID-19

3.1. Traditional phytotherapy

Traditional allopathic treatments are not available to people everywhere all over the world. When human is a fight over COVID-19, it is either an expensive or insufficient infrastructure or absence of trained physicians even ratio of doctors and patient should be high [23]. Prior study reported that one physician was recruited per 30,000–100,000 people in Nepal. On the other hand, huge number of ethno-medicinal plants were available in higher in the mountains of Himalayas [24]. Herbal treatments which are easier than others mainly depend upon oral administration of living or dried plant extracts, or in tablets or capsules form. For that reason, mainly tribal people or rural are also fully or partially depends upon herbal medicine. The control of viral infection used by medicinal plant has largely historical and anecdotal evidence. Among several developing countries, some area of Indian people also depends upon Ayurvedic, flock medicine, Unani and Siddha, for control infectious disease including jaundice. Not only India, China also depends upon Ayurvedic plant beside traditional drug [25]. Several viral diseases controlled by many medicinal plant extract [26–28]. Thyagarajan et al. (1988, 1990) reported that dried milled Phyllanthus amarus was successful in clearing hepatitis B surface antigen (HBsAg) from blood positive carrier in Madras, India. The potential of medicinal herbs Acacia nilotica, Boswellia carterii, Embelia ribes, Piper cubeba, Quercus infectoria, Trachyspermum ammi and Syzygium aromaticum extracts were investigated in vitro and a significant inhibiting activity against HCV protease were reported [29]. Andrographis paniculate produce andrographolide which significantly arise CD4+ lymphocyte level of HIV patient [30] (Fig. 1 & Table-1).

3.2. Route of administration of phytotherapy by traditional plants

The main route is ingestion of plant material that may be living or dried [11]. Several parts of plant were used for ethno-medicinal preparations that were fruit, bark, flower, leaf, stem, seed, root, rhizome, wood, and even whole plant. Several underground parts! were frequently used, and this was recognized to availability of dominant bioactive compounds [31]. Bioactive plant product also applied as juice, oil, powder, latex, vegetable, paste, raw/fresh and resin. Plant juice (39.13%) was most commonly used, followed by decoction (13.04%), paste (10.86%), etc. The most popular forms of medicinal preparations in western Nepal are juice, decoction, paste, infusion, and powder [32] (Fig. 2 & Fig. 3).

4. Overview of traditional medicinal plants worldwide

Virus are randomly mutated with respect to environment and resistance towards antiviral agents [33]. In this critical situation viral diseases prevention is the global issue for safeguard of public health. Regardless lack of suitable immunization and appropriate medicine preparation are vital hindrance in our society [34]. At that time ethno-medicine is an alternative way to control viral infection. Although, the usage of medicinal herbs is an old-age practice but modern traditional therapeutics also stimulated by natural ethno-medicine for the control of many diseases. The medicinal plants have potent therapeutic value due to
synthesis of several important bioactive metabolites include flavonoids and phenols (antioxidant), alkaloids (antibacterial, antimalarial, anti-parasite, analgesic and anti-allergenic) and terpenoids (anti-helminthic, anti-virus, anti-bacteria, anti-inflammatory, and antimalarial, anticancer) activity [35]. In this age of globalization, people are abandoning synthetic drugs as in ancient times and relying on trees for proper treatment. At present, various types of medicinal herb are available in tropical portion of earth those are rich in huge useful phytochemicals that have not only antimicrobials (namely, antiviral, antibacterial and antifungal) activity but also use in several purpose like cardiovascular treatment, neuronal treatment, diabetes etc. [36]. In this circumstance various researchers of Europe, Asia even America have given commitment to development of antiviral drug from their native traditional herbs. At present many herbal based companies were developed and they marked world basis through formulating new type of herbal based medicine. Medicinal plants have a several types of potent chemical constituents, which able to inhibit the replication and penetration of a group of RNA or DNA containing viruses [37]. Several bioactive
Antiviral Phytochemicals

**Fig. 4.** Molecular mechanism of phytochemicals.

Phytochemicals are strong common antiviral agent such as polysaccharides, alkaloids, lectins, proteins, terpenes, flavonoids, polyphenols, etc. but their mode of action are different. Among strong bioactive compound polysaccharides, prevent viral attachment and replication but lectins can block viral entry inside of host, alkaloid prevents viral growth, terpene (saponins) inhibits the replication of virus and flavonoids are able to inhibit reverse transcriptase.

Previously reported that glycosides have antifungal and antibacterial activities; but saponins have anti-inflammatory, antiviral activities [35]. On the other hand, topotecan and irinotecan (derived from dengue virus, enterovirus 71 (EV71) human immunodeiciencies; but saponins have anti-inflammatory, antiviral activities against herpes simplex virus (HSV), poliovirus type 1, coxsackie virus, respiratory syncytial virus and even Corona virus [40]. Beside infectious diseases, genetic diseases also control by herbal medicine against selected viruses.

6. Antiviral activity of herbal medicine against selected viruses

Many traditional medicinal plants have been reported to have strong antiviral activity and some of them have already been used to treat animals and people who suffer from viral infection [55-58]. Research interests for antiviral agent development was started after the Second World War in Europe and in 1952 the Boots drug company at Nottingham, England, examined the action of 288 plants against influenza A virus in embryonated eggs. They found that 12 of them suppressed virus amplification [59]. During the last 25 years, there have been numerous broad-based screening programmes initiated in different parts of the globe to evaluate the antiviral activity of medicinal plants for in vitro and in vivo assays. Canadian researchers in the 1970s reported antiviral activities against herpes simplex virus (HSV), poliovirus type 1, coxsackie virus B5 and echovirus 7 from grape, apple, strawberry and other fruit juices [60,61]. One hundred British Columbian medicinal plants were screened for antiviral activity against seven viruses [62]. Twelve extracts were found to have antiviral activity at the concentrations tested. The extracts of Sambucus racemosa completely inhibited respiratory syncytial virus (RSV). An extract of Ipomoea aggregata demonstrated good activity against parainfluenza virus type 3. A Lomatium dissectum root extract completely inhibited the cytopathic effects of rotavirus. In addition to these, extracts prepared from Cardamine angustifolia, Conocephalum conicum, Lysichiton americanum, Polypodium glycyrrhiza and Verbasum Thapsus exhibited antiviral activity against herpes virus type 1. The extracts of 40 different plant species have been used in traditional medicine and were investigated for antiviral activity against a DNA virus, human cytomegalovirus (HCMV), and two RNA viruses, Ross River virus (RRV) and poliovirus type 1, at noncytotoxic concentrations [63]. The most active extracts were the aerial parts of Pterocaulons phacelatum.
Many people can use various plant simultaneously with several drug. Although all over world can suffer corona virus but infectivity rate significantly slow in many tribal based states of India like Sikim, Nagaland, Himachal Pradesh, Jharkhand etc., [73]. On the other hand, few people of Bankura and very less people of Purulia district West Bengal can suffer by COVID-19. Beside Purulia, Sikim, Nagaland, Meghalaya and many other regions cover by mainly tribal community. They also depend upon various medicinal plant for treatment of any disease. When total world uses chemical drugs then tribal people based on the selective plant for precaution and treatment of corona infection [74]. Plants selected by three basic steps (1) The plants were selected by survey report from tribal people (2) Verified by PubMed for those herbs conventionally used to treatment viral respiratory infections. (3) In vivo, general effect prediction with network pharmacology analysis. Bacteria and viruses, pandemic diseases are spreading. It seems to us out of control and we think ourselves helpless, unsafe. So, we are now in endangered position for human civilization. Many would be glad to learn that the much common villagers and the tribal people strictly use herbal medicine to cure disease [75]. They are healthier than others. According to survey report from tribal zone of Purulia district, West Bengal, India several plants use as traditional herbs for treatment of COVID-19 and influenza, those are including in Table 1.

| Plant Name                  | Antiviral Activity against Viruses |
|----------------------------|------------------------------------|
| Sanicula europaea          | HSV-1, VSV, poliovirus type 1      |
| Eleutherococcus senticosus | HSV-1, VSV, adenovirus             |
| Pittosporum phylliraeoides | HSV-1, VSV, adenovirus             |
| Pittosporum ptylliroideas | HSV-1, VSV, adenovirus             |
| Holoptelia integrifolia   | HSV-1, VSV, adenovirus             |
| Dianella longifoliavar. grandis | HSV-1, VSV, adenovirus         |
| Pittosporum subsp. glabra  | HSV-1, VSV, adenovirus             |
| Pittosporum australis      | HSV-1, VSV, adenovirus             |
| Dianella longifoliavar. grandis | HSV-1, VSV, adenovirus         |
| Pittosporum subsp. glabra  | HSV-1, VSV, adenovirus             |
| Pittosporum australis      | HSV-1, VSV, adenovirus             |
| Dianella longifoliavar. grandis | HSV-1, VSV, adenovirus         |

8. Mechanism and targeting site of COVID: potential herbal compound

A group of herbal derived chemical compounds have potential antiviral properties, but the mechanisms of action are different. The first target sites are glycoproteins of virus envelope that leading to as nonspecific binding to host cells (human cell receptors of respiratory cells ACE2) [84]. However, the actual chemical constituent in the research used to treat the infection was not identified. There are different types of plant flavonoids may be used to treat the symptoms of SARS-CoV3CL by inhibition of essential protein synthesis process of the virus [85]. After the entries of virus into host cell, ‐ss RNA attach to the host ribosome during translation of two kinds of large, co‐termal polyproteins that are necessary for packaging new virions [86]. Herbal therapeutics able to target spike, RdRp, 3CLpro, and PLpro of SARS-CoV2 [87,88]. SARS-CoV2 shares about 82% resemblance of genomic sequence identity with SARS-CoV's and more than 90% resemblance of sequence identity in several essential enzymes [89]. Several natural herbal compounds such as theaflavin and cephamephrine repressed SARS-CoV2 by defeating RdRp and ACE activities; hirsutenone e and tanshinoines I–VII showed antiviral action against SARS-CoV via obliging the PLpro activity, while pristimerin, celastrol, iguesterin, tingenone, chalcones I–IX and quercetin-3-β-galactoside were able to inhibit SARS-CoV by defeating the 3CLpro activity [90] (Table 2).
Fig. 6. Images are representing the docking interactions between herbal compounds with Human Furin (4RYD).
| Sl. no. | Botanical Name & family | Local name | Part used | Method of use in | Treatment for | References |
|--------|------------------------|------------|-----------|------------------|--------------|------------|
| 1      | Cinnamomum zeylanicum Blume (Lauraceae) | Cinnamon | Bark | 1 teaspoon natural honey + 1/4 tea spoon bark dust | Influenza, HSV-1 viruses, Parainfluenza virus | Patil et al., 2020 |
| 2      | Jatropha curcas L. (Euphorbiaceae) | Physic nut/varendra | All parts, mainly latex | Latex with candy | Influenza, HIV | Agrawal et al., 2020 |
| 3      | Glycyrrhiza glabra L. (Fabaceae) + Honey | Licorice | Root | Extract Mixture | Influenza + covid 19 | Huacho-Rojas et al., 2020 |
| 4      | Piper chabu | Pippali or long Pepper ginger | Fruit, + Rhizome | Juice (certain quantity) | Influenza | John et al., 2020 |
| 5      | Piper nigrum L. (Piperaceae) + Syzygium aromaticum (L.) Merr. & L.M.Perry (Myrtaceae) + (Buch.-Ham.) T.Nees&G.H.Eberm. (Lauraceae) + Camellia sinensis (L.) Kuntze (Theaceae) | Black pepper | Fruit (piper) + Flower bud (syzyg) + Leaf (Cinnamon) + Leaf (Camellia) | As tea (certain quantity) | Influenza | Narkhede et al., 2020 |
| 6      | Oxalis corniculata. (Oxalidaceae) | Amruli | Mainly leaf, steam | As vegetables | Influenza | Ding et al., 2021 |
| 7      | Averrhoa carambola L. (Oxalidaceae) | Starfruit | Green and ripe fruit | As fruit | Influenza | Barile et al., 2020 |
| 8      | Nigella sativa L. (Ranunculaceae) | Kalonji/Black cumin | Seed | Mixed with honey | Influenza | Islam et al., 2021 |
| 9      | Adhatodavasica Nees (Acanthaceae) + Ocimum sanctum L. (Lamiaceae) | Bakash + Holybasil | Leaf (adhato.) + Spadix (ocim.) | As juice (certain quantity) | Influenza | Chernyshov et al., 2020 |
| 10     | Ziziber officinale Roscoe (Zinziberaceae) + Allium cepa L. (Liliaceae) + Capsicum frutescens L. (Solanaceae) | Ginger, Onion&Chilli | Rhizome, Scale leaf&Green fruit | As fruit (certain quantity) | Influenza | Pal et al., 2019 |
| 11     | Allium sativum L. (Liliaceae) | Garlic | Raw scale leaf | (certain quantity) | Influenza | Rouf et al., 2020 |
| 12     | Cirtus limon (L.) Osbeck (Rutaceae) | Lemon | Fruits | Mixed with tea or water | Influenza | Hakim et al., 2020 |
| 13     | Oxalis corniculata. (Oxalidaceae) | Amruli | Mainly leaf and steam | As vegetables | COVID-19 | Navarro-Leon et al., 2020 |
| 14     | Anadrichandra A.Juss.(Maliaceae) | Neem | Leaf | As vegetables | COVID-19 | Borkosky et al., 2020 |
| 15     | Daucuscarota L.(Apiaceae) | Carrots | Root | As vegetables | COVID-19 | Haryanto et al., 2021 |
| 16     | Morinap (Moringaceae) | Drumstick tree | Leaf and fruit | As vegetables | COVID-19 | Meierles et al., 2020 |
| 17     | Momordica charantia. (Cucurbitaceae) | Karela | Leaf and fruit | As vegetables | COVID-19 | Fedougou et al., 2020 |
| 18     | Ficus benghalensis(L.) (Moraceae) | Fig | Fruit | As vegetables | COVID-19 | Hassan et al., 2020 |
| 19     | Glinusoppositifolius(L.) Aug.DC.(Molluginaceae) | Cuisine/Gima | Leaf | As vegetables | COVID-19 | Wiart et al., 2020 |
| 20     | Spinacia oleracea L.(Amaranthaceae) | Spinach | Leaf | As vegetables | COVID-19 | Borkosky et al., 2020 |
| 21     | Nyctanthes arbor-tristis L.(Oleaceae) | Night jasmine/Sueli | Leaf | As vegetables | COVID-19 | Bhattacharya et al., 2016 |
| 22     | Mangifera indica L. (Anacardiaceae) | Mango | More sour green fruit | As Fruit | COVID-19 | Yang et al., 2020 |
| 23     | Ananascomosus (L.) Merr.(Bromeliaceae) | Pineapple | Fruit | As juice/fruit | COVID-19 | Kumar et al., 2020 |
| 24     | Spondias pinnata (L.) Kurz(Anacardiaceae) | Amyra | Fruit | As vegetables | COVID-19 | Li et al., 2020 |
| 25     | Tamarindus indica L. (Fabeaceae) | Tamarind | As vegetables | COVID-19 | Borquaye et al., 2020 |
| 26     | Emblica officinalis L. (Phyllanthaceae) | Emblica | Fruit | As vegetables | COVID-19 | Akbar et al., 2020 |
| 27     | Cirtus limon(L.) Osbeck(Rutaceae) | Lemon | As juice | COVID-19 | Yousaf et al., 2018 |
| 28     | Aegle marmelos(L.) Correa(Rutaceae) | Stone/golden apple | Fruit, Leaf | As fruit, juice | COVID-19 | Akbar et al., 2020 |
| 29     | Chebulic myrobolan (Terminalia chebula) Retz. (Combretaceae) | Haritaki | Fruit | Fruit dust | COVID-19 | Hoque et al., 2021 |
| 30     | Oxalis corniculata L(Oxalidaceae) | Amruli | Mainly leaf and steam | As juice | COVID-19 | Vilela et al., 2021 |
| 31     | Tinospora cordifolia (Thunb.) Miens(Menispermaceae) | Giloy/guduchi | Mainly leaf and steam | As juice | COVID-19 | Singh et al., 2021 |
| 32     | Coris papaya L. (Guttiferae) | Pawpaw | Mainly leaf; Latex from fruit with candy | As juice | COVID-19 | Baroosh et al., 2020 |
| 33     | Andrographis paniculata (Burm.f.) Nees(Acanthaceae) | Kalmegh | All parts | As juice and tablet | COVID-19 | Dharmadasa et al., 2020 (continued on next page) |
9. Energy minimization and molecular docking of phytochemicals derived from traditional plants

Medicinal plants always provide useful benefits to humankind. Here we have studied an in-silico docking experiment among the compounds of medicinal plants with human furin protease (PDB: 4RYD). The purpose of the study is to establish how the components of medicinal plants help us to develop immunity in our body. Protein Data Bank file for Human Furin (PDB ID: 4RYD) was used as receptor molecule and list of herbal compounds isolated from different medicinal plants were taken as ligand molecule for docking. Each molecule was undergone energy minimization using ChemBio3D Ultra 13.0 software, a high-quality workstation and the molecule for docking. The iGEMDOCK software was used for the docking studies of compounds isolated from different medicinal plants were taken as ligand for Human Furin. The iGEMDOCK v2.1 software was used for the docking studies of compounds isolated from different medicinal plants were taken as ligand for Human Furin.

Table 1 (continued)

| SL no. | Botanical Name & family | Local name | Part used | Method of use in | Treatment for | References |
|-------|-------------------------|------------|-----------|------------------|--------------|------------|
| 34    | Azadirachta indica A.Juss. (Meliaceae) + Curcuma longa (Zingiberaceae) | Neem | Mainly leaf and fruit | As juice | COVID-19 | Tilla et al., 2020 |
| 35    | Morinda charantia L. (Rubiaceae) + Vitex negundo L. (Lamiaceae) + Nux vomica (Vitaceae) | Karelia | Leaf | As juice | COVID-19 | Divya et al., 2020 |
| 36    | Piper nigrum L. (Piperaceae) + Syzygium cumini (L.) Merr. & L.M.Perry (Myrtaceae) + Cinnamomum tamala (Buch. - Ham.) T. Nees & H. Eberm. (Lauraceae) + Canellainnamonus L. (Zingiberaceae) | Black pepper | Fruit dust 1 teaspoon | As tea | COVID-19 | Tasleen et al., 2021 |
| 37    | Piper nigrum L. (Piperaceae) + Cinnamomum zeylanicum Blume (Lauraceae) + Ocimum sanctum L. (Lamiaceae) + Ziziphus officinalis Roscoe (Zingiberaceae) + water & Salt | Black pepper | Fruit dust 1 teaspoon | As tea | COVID-19 | Sulaiman et al., 2021 |
| 38    | Terminalia chebula Retz. (Combretaceae) + Piper nigrum L. (Piperaceae) + Cinnamomum zeylanicum Blume (Lauraceae) + Ocimum sanctum L. (Lamiaceae) + Water & Salt | Haritaki | Fruit dust 1 teaspoon | As tea | COVID-19 | Patel et al., 2021 |
| 39    | Glycyrrhiza glabra L. (Fabaceae) + Cinnamomum zeylanicum Blume (Lauraceae) + Terminalia chebula Retz. (Combretaceae) + Anomum subulatum Roxb. (Zingiberaceae) + Ocimum sanctum L. (Lamiaceae) + Water & Salt | Licorice | Root dust 1 teaspoon | As tea | COVID-19 | Hejazi et al., 2021 |
| 40    | Cinnamomum cassia (L.) J.Presl (Lauraceae) + Cynara cardunculus (L.) Osbeck (Rutaceae) + Ziziphus officinalis Roscoe (Zingiberaceae) + water & Salt | Cinnamon | Bark dust 2 teaspoon | As tea | COVID-19 | Chauhan et al., 2021 |
| 41    | Anamomus subulatum Roxb. (Zingiberaceae) + Cinnamomum cassia (L.) J.Presl (Lauraceae) + Ziziphus officinalis Roscoe (Zingiberaceae) + Allium sativum L. (Amaryllidaceae) + Cynara cardunculus (L.) Osbeck (Rutaceae) + Dracaena scorpius L. (Dracaceae) + water & Sal | Cardamom | Big 10 | As vapour and | COVID-19 | Shah et al., 2020 |
| 42    | Nepeta sativa L. (Lamiaceae) + Glycyrrhiza glabra L. (Fabaceae) + Piper nigrum L. (Piperaceae) + Cicer arietinum L. (Fabaceae) + Anomum subulatum Roxb. (Zingiberaceae) + Ferula afghanica L. (Umbelliferae) + Vitix vinifera L. (Vitaceae) + Honey | Black carmin/kalonji | Seed dust (Ne) + Root dust (Gly) + Fruit dust (Pi) + | As mixture | COVID-19 | Joshi et al., 2021 |
| 43    | Allium sativum L. (Amaryllidaceae) + Ziziphus officinalis Roscoe (Zingiberaceae) + Piper nigrum L. (Piperaceae) + Datura candida (Apiaceae) + Foeniculum vulgare Mill. (Apiaceae) + Ocimum sanctum L. (Lamiaceae) + Vigna radiata (L.) R. Wilczek (Fabaceae) + Honey | Garlic | Scale leaf (Alii) + Rhizome (Zin) + fruit (pipe) + root | As mixture | COVID-19 | Daniell et al., 2021 |
| 44    | Ferula afghanica L. (Umbelliferae) + Glycyrrhiza glabra L. (Fabaceae) + Cinnamomum cassia (L.) J.Presl (Lauraceae) + Curcuma longa (Zingiberaceae) + Camphor (L.) J.Presl (Lauraceae) + Honey | Hing | Turpentine oil | As mixture | COVID-19 | Fasih et al., 2020 |
| 45    | Justicia adhatoda L. (Acanthaceae) + Glycyrrhiza glabra L. (Fabaceae) + Cinnamomum cassia (L.) J.Presl (Lauraceae) + Camphor (L.) J.Presl (Lauraceae) + Honey | Hing | Turpentine oil | As mixture | COVID-19 | Fasih et al., 2020 |
| 46    | Glycyrrhiza glabra L. (Fabaceae) + Cinnamomum cassia (L.) J.Presl (Lauraceae) + Camphor (L.) J.Presl (Lauraceae) + Honey | Hing | Turpentine oil | As mixture | COVID-19 | Fasih et al., 2020 |
| S.No | Name of plant | Major compound | Reference |
|-----|--------------|----------------|-----------|
| 1   | Cinnamomum zeylanicum | Eugenol | Asif et al., 2020 |
| 2   | Jatropha curcas | Tannic acid, dioxigenin, Phorbol esters, gallic acid, pyrogallol rutin, myricetin and daidzein, apigenin and its glycosides, vitexin and isovitexin, stigmasterol, β-sitosterol| Oskoueian et al., 2011 |
| 3   | Glycyrrhiza glabra | Asparagine, tannins, glycosides, resins, sterols, volatile oils, Glycyrrhizin (glycyrrhizic acid; glycyrrhizinate), tripterpenoid aglycone, glycyrrhetic acid (glycyrrhetic acid; enoxolone), Glycyrrhizin and glycyrrhetic acid, glycyrrhetinic acid, Carbonoxole (18-fluglycyrrhetinic acid hydrogen succinate), e irisin, isoorientin, liquiritigenin and rhamnocytisuloses. Five new flavonoids: glucoisoorientinapnoside, shinflavane, shintoerpacerin, prenylllicflavone A, and 1-methoxypysica- seolin, glabridin and hispapagluridins A and B, both glabridin and glabresce have estrogen-like activity, many volatile compounds are present in roots e.g., geraniol, pentanol, hexanol, terpinen-4-ol, α-terpinol. Isolation of various compounds like propionic acid, benzoic acid, furfurdehyde, 2,3 butanediol, compounds like propionic acid, benzoic acid, furfurdehyde, 2,3 butanediol, | Monica et al., 2014 |
| 4   | Piper chaba | Piperonal, Methyl piperate, Pipercide, Sesamin, Piperarborenine E, Piperocaine, Piperchabamide D, Retrofractamide B, Retrofractamide C, Retrofractamide A, Piperchabamide A, Piperchabamide A, Hisashi et al., 2008 |
| 5   | Zingiber officinalis | 6-Shogaol, 6-Gingerol,8-Gingerol,10-Gingerol, Curcumín, Curcin, Curcic acid, Allicic acid, Allicic acid, Allicic acid, Allicic acid, Allicic acid, | Huang-yu Yeh et al., 2014 |
| 6   | Piper nigrum | Pinosolins, guainosine, Chavicine, 1-(2E,4E,8S)-(3,4-methylenediencylo- phenyl)2,4,6-trisopropylphenol, Piperidine, Piperine, Piparbernine, E, Paparbernine D, Paparberone C, Dehydroripipernalione and pipirrolen B, | Mgbearuokuru et al., 2017 |
| 7   | Piper longum | Longumosides A (1) and B (2), ethyro-1-(1-oxo-γ-(3,4-methylenediencylophenyl)-8,9-dihydroxy-2E-nenynyl) piperidine (3), and threo-1-(1-oxo-γ-(3,4- methylenediencylophenyl)-8,9-dihydroxy-2E-nenynyl) piperidine (4) were isolated, besides two new natural products 3b,4α-dihydroxy-2-piperidino- ne (5), 5,6-dihydro-(2H)-pyrididine (6) (Fig. 1). Compounds 2-6, together with the isolates previously obtained with a large amount from P. longum involving piperine (7),3,7,1 (1-oxo-γ-(3- methoxyl-4-hydroxyphenyl)-2E-pen- tenyl)piperidine (8),6,10 guineesine | Fatima et al., 2021 |
| 8   | Cinnamomum tamala | Monoterpenes (65.6%), The predominant monoterpenes were trans-sabinene hydrate (29.8%), (Z)-β-ocimene (17.9%), myrcene (4.6%), α-pinene (3.1%) and β-sabinene (2.3%). Among 21 sesquiterpenes (32.9%). | Showkat et al., 2004 |
| 9   | Camellia sinensis | Polyphenols epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (EEGC), epigallocatechin gallate (EGGC), caffeine, theanine, myricetin, quercetin, and kaempferol, which are examples of alkaloids, amino acids, and flavonoids, | Vanaara et al., 2018. |
| 10  | Curcas glabra | 1-([1-oxo-5(3,4-methyleneoxy-5H)-piperidine (8),6,10 guineesine inverting piperine (7),3,7 1-
| 11  | Oxalis corniculata | Two isolated compounds 5-hydroxy-6,7,8,4'-tremetahexoxyflavone (1) and 5,7,4'-trihydroxy-6,8-dimethoxyflavone (2) tannins, palmitic acid, a mixture of 8 oleic, linolenic, and stearic acids. Glycosides, phytosterols, phenolic compounds, flavonoids, proteins (12.5%), amino acids and volatile oil. | Kishor et al., 2017 |
| 12  | Nigella sativa | Thymoquinone (TQ), dithymoquinone, thymohydroquinone, thymol, carvacrol, nigelline-N-oxide, nigellicine, nigelline, and alpha-hedetin | Sharly et al., 2010 |
| 13  | Adhatoda vasica | 2-(4-but-2-yl) phenyl) propanoic acid, N, N-dimethylglycine n-hexadecanocacid. Ibuprofen, n-hexadecanocacid, N, N dimethylglycine Eugenol (1-hydroxy-2-methoxy-4-methylbenzene, euginal (also called aromatic eugenol), urosolic acid, (2,3,4,5,6,6α,7,8,8α,10,11,12,13,14β-dimethylocta-1,6-dien-3-ol, limatrol, methylphenol, linalool (3,7-eugenyl alcohol, carvacrol (5-isopropyl-2-methyl)-endo-terpinhyrazone from the essential oil is also reported | Priyabrata et al., 2010 |
| 14  | Cismum sanctum | Selvarani et al., 2014. | Priyabrata et al., 2010 |
| 15  | Allium cepa | Quercitin, fructose, quercitin-3-glucoside, isorhamnetin-4-glucoside, xylose, galactose, glucose, mannose, organosulfur compounds, allylsulfides, flavonoids, flavonols, S-alk(en)yl cysteine sulfonides, cycloallilin, selenium, thiosulfonates, and sulfur and seleno compounds | Lorendana et al., 2017 |
| 16  | Capsicum frutescens | Ester, terpenoids, lipoxynagen derivatives, carboxyls, alcohols, hydrocarbons 8, capsaicin, dihydrocapsaicin 4, capsoninoid 11, capsinoids, 8-methyl-6-nonenonic acid (capsaicin), 8-methylnononic acid (dihydrocapsaicin), 7-methylnononic acid (nordihydrocapsaicin), 9-methylnononic acid (homodihydrocapsaicin) and 9-methyl-urs-7-enonic acid (homocapsaicin). | Antonio et al., 2010 |
| 17  | Allium sativum | Allicin, diallyl disulfide, S-allylcysteine, and diallyl trisulfide, diallyl disulfide (DDS), S-allylcysteine (SAC) and diallyl trisulfide (DTS) | Peyman et al., 2013 |
| 18  | Oxalis corniculata | 5-hydroxy-6,7,8,4'-tremetahexoxyflavone (1) and 5,7,4'-trihydroxy-6,8-dimethoxyflavone, β-sitosterol, betulin, 4-hydroxybenzoic acid, ethyl gallate, methoxylflavones, apigenin, and 7-O-β-o-glucopyranoside, palmitic acid, oleic. | Sharma et al., 2014. |
The macromolecules were cleaned from water for the docking analysis. The software can work through Auto Dock Tools automated molecular dockings. AutoDock Vina software was also implemented with generic evolutionary algorithm (GA) to carry out the docking experiments.

### Table 2 (continued)

| Sl no | Name of plant | Major compound | Reference |
|-------|----------------|----------------|-----------|
| 19 Azadirachta indica | linoleic, linolenic and stearic acids, flavonoids, iso virexine and virexine-2" O- beta – o- glucopyronoside. Glycosides, limonoids, tetrasterepterinosid, coumiers, iso coumiers, kaempferol, quercetin, myricetin, 5,7,4 trihydroxyflavone, apigenin 7,0 glucoside. Azadirachitin A, B, D, H, I, Desacyethylamin, Azadiridine, Nimbin, Salanin, Azadirine, Nimboline, Nimbiline, Nimbolide. | Mohammad et al., 2007 | |
| 20 Daucus carota | p-hydroxybenzoic acid; caffeic acid; chlorogenic acid; and the anthocyanins. phenolics, carotenoids, polyacetylenes, and ascorbic acid. | Ahmad et al., 2019 | |
| 21 Moringa sp | Phenolic acids, flavonoids, isothiocyanates, tannins and saponins, N, o-c-rhamnopyranosylcoicosamide, 4- (a-L-rhamnopyranosylxylo) phenyl acetonitrile (niazin), pyrorealmuramine 4’-O-o-Lrhamnopyranoside, 4’-hydroxy phenylethynamidine- o-Lrhamnopyranoside (marumoside A) and its 3-0-D-glucopyranosyl- derivative (marumoside B) and methyl 4- (a-L-rhamnopyranosylxylo)- benzylcarbamate, 4-0-(a-L- acetylhannopyranosylxylo)-benzy glucosiotolates, deoxy-niazimicine (N- benzyl, Sethylthioformate) | Singh et al., 2017 | |
| 22 Momordica charantia | Momordicodiode ((10E)-3-hydroxy-dodec-10-en-9-olide, 1), monaricopside A (4-hydroxyl benzoic acid 4-O-beta-D-apiofuranosyl (1 2)-O-beta-g-glucopyranoside, 2), dihydrophaseic acid 3-O-beta-g-glucopyranoside (3), 6,9-dihydroxy-meganigman,4,7-dien-3-one (blumenol, 3) | Li et al., 2009 | |

was implemented with generic evolutionary algorithm (GA) to carry out automated molecular dockings. AutoDock Vina software was also used for the docking analysis. The software can work through Auto Dock Tools (ADT) or Pyrex tools [91]. The macromolecules were cleaned from water residues and Gasteiger charges were calculated. The ligands and macromolecules were uploaded in the Pyrex tool [92]. Finally, the receptor and ligand files were converted into pdbqt format.

While performing docking experiment of different herbal compounds isolated from different medicinal plants like Cinnamomum zeylanicum, Jatropha curcas, Glycyrrhiza glabra, Piper chaba, Zingiber officinalis, Piper nigrum, Piper longum, Cinnamomum tamala, Ocimum sanctum etc. screening of all these essential compounds present in these plants is our main aim of study. Here we have docked 66 different compounds with human furin protease. Out of 66 compounds, 30 compounds were shown not only strong binding affinity but also binds to the active site of the receptor molecule.

In silico docking study of cinnamaldehyde with furin protein clearly depicts a binding affinity of –64.25 kcal/mol (Table 3). Cinnamaldehyde interacts with the following residues D258, W254, G255, A292, S293, G294 of furin protein. Docking of proanthocyanidins with furin protein shows strong binding affinity of –125.73 kcal/mol. Pro-anthocyanidins binds with the residues H194, S253, G255, N295, S368, W254, E257, D258 of furinprotein (Fig. 6 & Table 3).

From the results of molecular docking, it is very much evident that all these herbal compounds have significant role in binding with furin protein thus preventing the viral entry with the human body.

### 10. Aspects of synergetic combination of medicinal plants with orthodox drugs for alleviating viral infection:

Strikingly it was seen that some patients of the Far East are use combination of orthodox medical drugs and herbal medicine for improving illnesses [93] as well as reduce the side effects of orthodox medical drugs, to extent better treatments. Although pharmacological appliances of the combinations are not well-studied but efficacious treatments by amalgamation of plant products with orthodox drugs were reported [94]. Acyclovir combines with Geranium robertianum, Actium lappa, Calendula officinalis and shows better results of ulcer [95]. Combined application of Verbascum thapsiforme (Scrophulariaceae) flowers and three amantadine derivatives enhance the inhibitory effect of influenza virus [96].

### 11. Biotechnology and high-tech herbal medicine

The many uses of medicinal plants need have led to encounter and overexploitation. An account of the multipurpose uses of ethnomedical plants in turn to be threaten for overharvesting in several countries including India [97]. Frequent forest fires and early harvests jeopardise existing populations of medicinal plants. The institution Malaysian Amchi Association (HAA), aimed at maintenance traditional knowledge about health care is enthusiastic to guard medicinal plants and strengthen the knowledge of several plant species including Amchi healers [98]. Due to climate change and exploitation of soil the quality and quantity of medicinal plants have been lost. Excess-harvesting was a tremendous threat to many indigenous medicinal plant species, like N. grandiflora, Z. armatum, A. rivalis etc [99]. Today biotechnology is an emergent ground all over world. It has numerous industrial applications, principally in health care sector, agriculture field, food industries and involve the maintenance of eco-sustainable environment. Microbes and phytochemicals are both sue as raw materials of biomedical industries. But all medicinal plants incapable to grow in any climate at selective season. So, mainly tissue culture technology can fulfil the crisis of phytochemicals. Plant secondary metabolites easily produce by tissue culture technique in adverse situation (loss of plant, habitat degradation). By this technique extinct species should be culture.

### 12. Future prospects

Now viral diseases are still serious, although few under control by proper life-prolonging drugs. But these more expensive drugs are still far beyond the developing countries. Perhaps, the expansion of innocuous, active and cheap antiviral drugs act as RT inhibitors (HIV and hepatitis) that are not yet curable. In spite of fact that, significant attention requires for screening of various medicinal plant and extraction of bioactive compound those act on especially viral diseases. Beside screening programme genus of species wise identification require and proper detection of useable parts of plant and optimise bioactive phytochemicals extraction method also most essential. Ultimately monitoring require for growth pattern and season (s) during deposition or maturation of materials as well as details of administration of phytochemicals [58]. Some herbs contain ribosome-inactivating proteins (RIPs) which can alter function of ribosome of infected cell and block viral protein synthesis [100].

### 13. Conclusion

Based on the more resemblance of the receptor and the genome of SARS-Cov and SARS-CoV2 this report tried to recommend potential plant species that might be involved as anti-SARS-CoV2 agents. Plant species can deliver a purely natural, low cost and with less side effects approaches of drug development strategy against COVID-19. Our study suggested the several plant species such as Oxalis corniculata, Ocimum sanctum, Cinnamomum zeylanicum, Moringa sp. etc might encounter the
Table 3
Energy minimization of ligands and determination of binding free energy of docking interactions between herbal compounds with Human Furin (4RYD) using iGEMDOCK.

| Sl. No. | Receptor            | Ligand                        | Energy Minimization of Ligand | Ligand Binding site | Binding Free Energy (kcal/mol) | Plant source           |
|--------|---------------------|-------------------------------|------------------------------|---------------------|--------------------------------|-----------------------|
| 1      | Human Furin:A       | Cinnamaldehyde (PubChem CID: 637511) | 5.373                        | D258, W254, G255, A292, S93, G94 | -64.25                  | Cinnamomum zeylanicum |
| 2      | Human Furin:A       | Proanthocyanidins (PubChem CID:122173182) | 46.1570                      | H194, S253, G255, N295, S368, W254, E257, D258 | -125.73               | Cinnamomum zeylanicum |
| 3      | Human Furin:A       | Eugenol (PubChem CID: 3314)   | 8.9422                       | N310, Q488, A532, G307, S311, Y313 | -67.36                  | Cinnamomum zeylanicum |
| 4      | Human Furin:A       | Piperchabamine B (PubChem CID: 44452655) | 26.9485                      | D233, P266, A267, W531, A532 | -81.24                  | Piper chaba          |
| 5      | Human Furin:A       | Diosgenin (PubChem CID: 99474) | 69.3497                      | N295, D153, H194, W254, G255, D258 | -83.51                  | Jatropha curcas      |
| 6      | Human Furin:A       | Phorbol ester (PubChem CID: 22833501) | 80.1299                      | G307, Q488, N529, V231, G265, P266, E271, R490, W531 | -90.75                  | Jatropha curcas      |
| 7      | Human Furin:A       | Gallic Acid (PubChem CID: 370) | 2.4714                       | N310, D132, Q488, G307, S311, W351 | -65.83                  | Jatropha curcas      |
| 8      | Human Furin:A       | Pyrogallol (PubChem CID: 1057) | 1.0761                       | W254, W291, A292, G255, S293, G294 | -73.30                  | Jatropha curcas      |
| 9      | Human Furin:A       | Rutin (PubChem CID: 5280805)  | 39.8640                      | K261, G265, R490, R498, G527, N529, T262, V263, F264, P528, D530, W531 | -118.61                 | Jatropha curcas      |
| 10     | Human Furin:A       | Myricetin (PubChem CID: 5281672) | 13.5507                      | A412, T413, S512, T514, H537, H422, T511 | -100.80                 | Jatropha curcas      |
| 11     | Human Furin:A       | Diadzein (PubChem CID: 5281708) | 16.2532                      | S253, R386, H194, S253, W254, G255, D258, G294, N295, S368 | -86.60                  | Jatropha curcas      |
| 12     | Human Furin:A       | Apigenin (PubChem CID: 5280443) | 20.6339                      | N310, N529, A532, G307, S311, W531 | -86.53                  | Jatropha curcas      |
| 13     | Human Furin:A       | Vitexin (PubChem CID: 5280441) | 37.1296                      | G255, N295, W254, P256 | -100.39                 | Jatropha curcas      |
| 14     | Human Furin:A       | Stigmasterol (PubChem CID: 5280794) | 57.5356                      | S311, I312, G307, N310, N529, W531, A532 | -95.87                  | Jatropha curcas      |
| 15     | Human Furin:A       | Beta-sitosterol (PubChem CID: 222284) | 61.7182                      | W254, G255, E257, D258, N295, R298 | -76.61                  | Jatropha curcas      |
| 16     | Human Furin:A       | Quercetin (PubChem CID: 5280343) | 19.2953                      | S253, W254, D258, S293, G294, N295, S368, G255, P256 | -92.62                  | Jatropha curcas      |
| 17     | Human Furin:A       | Coumarin Acid (PubChem CID: 5280841) | 8.7769                       | N310, S311, I312, Q488, G307, W531 | -61.24                  | Jatropha curcas      |
| 18     | Human Furin:A       | Benzoic Acid (PubChem CID: 243) | 5.1257                       | S311, I312, Q488, G307, N310 | -51.31                  | Jatropha curcas      |
| 19     | Human Furin:A       | Salicylic Acid (PubChem CID: 338) | 5.9864                       | R197, R193, H364, H194, T365 | -66.84                  | Jatropha curcas      |
| 20     | Human Furin:A       | Tannins (PubChem CID: 250395)  | 30.5261                      | H194, L227, S253, W254, G255, D258, N295, S368, D153, G294 | -126.02                 | Glycyrrhiza glabra  |
| 21     | Human Furin:A       | Asparagine (PubChem CID: 6267) | 0.6768                       | W254, P256, D258, W291, A292, N295, E106, G255, G294 | -73.96                  | Glycyrrhiza glabra  |
| 22     | Human Furin:A       | Piperine (PubChem CID: 638024)  | 22.3105                      | H405, Q129, D131, N133, D430 | -83.07                  | Piper chaba          |
| 23     | Human Furin:A       | Pipernonaline (PubChem CID: 9974555) | 25.6848                      | G255, D258, H364, H194, W254, N295, T365 | -83.42                  | Piper chaba          |
| 24     | Human Furin:A       | Sterol (PubChem CID: 1107)    | 46.5331                      | R391, V444, A445, V278, S279, T389, W390, Q447 | -71.34                  | Glycyrrhiza glabra  |
|        |                     |                               |                              |                      |                                | Oxalis corniculata    |
|        |                     |                               |                              |                      |                                | Jatropha curcas      |
|        |                     |                               |                              |                      |                                | Oxalis corniculata    |
|        |                     |                               |                              |                      |                                | Glycyrrhiza glabra   |
|        |                     |                               |                              |                      |                                | Daucus carota        |
|        |                     |                               |                              |                      |                                | Daucus carota        |
|        |                     |                               |                              |                      |                                | Citrus bergamia      |

(continued on next page)
defence, treatment against COVID-19 disease. However, the key com-
posite in those species to obstruct SARS-CoV is still unclear but in recent
years many bio-active compounds have been purified from natural her-
based on methyl gallate, gallic acid, quercetin, quercitrin, rutin, 
(-)-epicatechin, (-)-epicatechin gallate, kaempferol, beta-sitosterol, stigmasterol, 
kaempferol-3-O-glucoside, beta-sitosteryl-glucoside, phytol and tosendsa-
in [101]. Among such plant product, lectins (Uricaricin agglutinin) 
and secondary metabolites such as Baicalin and Glycyrrhizin have shown 
 promising results in SARS-CoV as well as an encouraging in-silico 
outcomes in the COVID-19 disease (Table 4). On the other hand, querc- 
etin, has been reported to have antiviral activity against HIV-luc/SARS
[102]. Meanwhile, numerous studies have tried to practice the plants as a 
bioractoer to express the SARS vaccinal agents or to overexpress the 
vaccinal agents. Overall, further studies are required in order to more 
assess the anti-viral capability of plant species. Such plant derived 
compounds might be a better choice for further research toward finding 
a novel herbal-based treatment approach. In this study, among more than 
40 number of herbal plants along with their composition analysis,
Glycyrrhiza glabra is the best one as they have the principals compounds like tannins, carbenoxolone, triterpenoid and glycyrrhizin which showed the highest binding ability with furin protease, followed by Cinnamomum zeylanicum and Jatropha curcas. The knowledge of numerous native plants from village elderly and local healers can be of massive significance to the local people and herbal medicinal researchers.

**Author’s contribution**

Sanjoy Pal, Trinath Chowdhury, Kishalay Paria, Sounik Manna, Sana Parveen, Pralay Sharma and Sk Saruk Islam collected the data and wrote the manuscript. Santit M Mandal and Sk Md Abu Imam Saadi supervised and corrected the manuscript. All authors agree to be accountable for all aspects of work ensuring integrity and accuracy.

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**Table 4**

| Binding free energy | Compound name | Source of the compound |
|---------------------|---------------|------------------------|
| -126.02             | Tannins       | Glycyrrhiza glabra     |
| -125.73             | Proanthocyanidins | Cinnamomum zeylanicum |
| -118.61             | Quercetin      | Jatropha curcas        |
| -106.93             | Carbenoxolone  | Glycyrrhiza glabra     |
| -106.91             | Glycyrrhizin   | Glycyrrhiza glabra     |
| -102.97             | Triterpenoid   | Glycyrrhiza glabra     |
| -101.55             | Curcumin       | Zingerol officinale    |
| -100.80             | Myricetin      | Jatropha curcas        |
| -100.39             | Vitexin        | Jatropha curcas        |
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