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Phytochemical Analysis, Antioxidant Activity of Wild Medicinal Plants of Himalayan Range

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ABSTRACT

Plants that are indigenous to the Himalayas have been exploited for their therapeutic properties for over 6,500 years. Using their deep knowledge of the local flora and fauna, traditional healers in the region are able to treat a wide variety of maladies with herbal treatments. People who live in rural areas of the Himalayas rely on wild medicinal plants for their health, and we need to do everything in our power to ensure that these plants continue to thrive in the harsh desert climate of the Himalayas. Raw materials that are obtained from wild plants are in high demand all around the world, particularly among pharmaceutical companies, ethnomedics, and practitioners of traditional medicine as well as other medical practitioners. India has been a top exporter of raw herbal medications all over the world. This is mostly due to the number of medicinal plants that can be found in the Himalayas. The aim of this study was to determine the Phytochemical analysis and antioxidant activity of various parts of 20 selected wild medicinal plants, found in the Himalayan regions in India, China, Nepal, Bhutan and Pakistan including *Swertia bimaculate, Ficus neriifolia, Rubus treutleri, Periploca calophylla, G. depressa, Buddleja napaulensis, Habenaria edgeworthii, Pyracantha crenulate, Roscoea procera, Allium rubellum, Berberis chitria, Capsella bursa-pastoris, Artemisia maritima, C. glanduliferum, C. distans, Juniperus macropoda, Origanum vulgare, Valeriana jatamansi, Polygonatum verticillatum, Meconopsis aculeate* and *Fragaria nubicolais*. There were several different parts of the species that were examined to determine their total polyphenol, flavonoid, alkaloid, saponin, and tannin concentrations. One fraction of the plant extracts was found to contain a higher quantity of phytochemicals when compared to the other portions. Through the utilisation of the DPPH and FRAP model systems, the antioxidant capacity of a number of different components was assessed. The high-performance liquid chromatography (HPLC) technique can be combined with the DPPH and/or ABTS tests in order to rapidly screen extracts for the presence of active chemicals.

Keywords- Medicinal plants, Himalayan range, antioxidant, phytochemical.

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I. INTRODUCTION

There are a lot of indigenous and rural communities in developing countries that place a lot of importance on herbal treatments. People all around the world prefer herbal therapies to conventional ones. Herbal remedies are more popular than conventional ones [1]. According to the World Health Organisation, over sixty percent of people living in rural areas of India use herbal treatments. This represents an estimated eighty percent of the world's population that relies on traditional medicine. Over the past few years, there has been a rise in the consumption of herbal supplements that ranges from 2.5 to 12 percent [2]. Traditional Indian medical theories and practices, such as Ayurveda, Siddha, Unani, and others, are responsible for providing primary healthcare, particularly for people living in rural areas. There are a number of factors that have contributed to the meteoric rise of the traditional knowledge system to the forefront of world affairs [3]. These factors include conservation, sustainable development, and the exploration of novel patterns of plant resource utilisation. Due to the fact that they use a wide variety of plants, both wild and cultivated, to treat a wide range of illnesses, they have access to a plethora of information regarding medicinal plants [4]. medical and aromatic plants (MAPs) make up a disproportionate amount of today's pharmaceuticals because they are the key components employed in the majority of health tonics and medical products that are available for purchase in the marketplace. It is estimated that some 70,000 different plant species are utilised in folk medicine around the world. Because medicinal plants are the primary source of bioactive compounds, the creation of new drugs is dependent on them [5]. In addition to this, sixty percent of the world's population and eighty percent of the population in developing countries rely on traditional medicine, which involves the use of plant parts from hundreds of different medicinal species in their natural state. The Indian Himalayan Region (IHR) is home to a number of species that are classified as critically endangered and extremely valuable [6].

The Himalayan Centre of Plant Diversity is a narrow band of biodiversity that may be found on the southern edge of the Himalayas (figure 1), which is the tallest mountain range in the world with heights that are higher than 8000 meters. In this altitudinal zone, which is typified by monsoon alrains (up to 10,000 mm of rainfall, concentrated in the summer), tropical lowland rainforests (one hundred to one hundred meters above sea level) and alpine meadows (four thousand eight hundred to five thousand meters above sea level) can be found [7]. A total of over 6,000 species of higher plants may be found in Nepal, with 303 of those species being indigenous to the country and another 1957 being found exclusively in the Himalayan region for the first time. In the Indian Himalaya, there are over 8,000 different species of vascular plants, and 1748 of those species are capable of being used for medicinal purposes [8]. One of the most essential functions of antioxidants is to reduce oxidative stress, which is a type of stress that can cause damage to biological components. Many people are of the opinion that the curative effects of medicinal plants can be attributed to the antioxidant capabilities of these plants, specifically the polyphenolic compounds and antioxidant vitamins [9]. Extracts of plants and the components that make up those extracts have been shown to demonstrate biological activity, according to research. Alkaloids, tannins, flavonoids, and phenolic compounds are some of the substances that can be found in a wide variety of therapeutic plant parts. These plant parts include stems, roots, leaves, barks, blooms, fruits, and seeds [10]. Herbs from the Himalayas have been utilised by a wide variety of people, including physicians, dietitians, flavorers, drinkers, dyers, repellents, perfumers, cosmeticians, and factories [11]. At the moment, around 121 of these substances are derived from plants that are found in the Himalayas, and they are responsible for almost 25 percent of the medication that is delivered all over the world [12]. Regrettably, the bulk of the region's higher plant species have never been described or even scanned for biologically active components. This is because there has not been sufficient deployment of biotechnology in the region. The information that is present regarding these plants is fundamental and limited in scope [13].

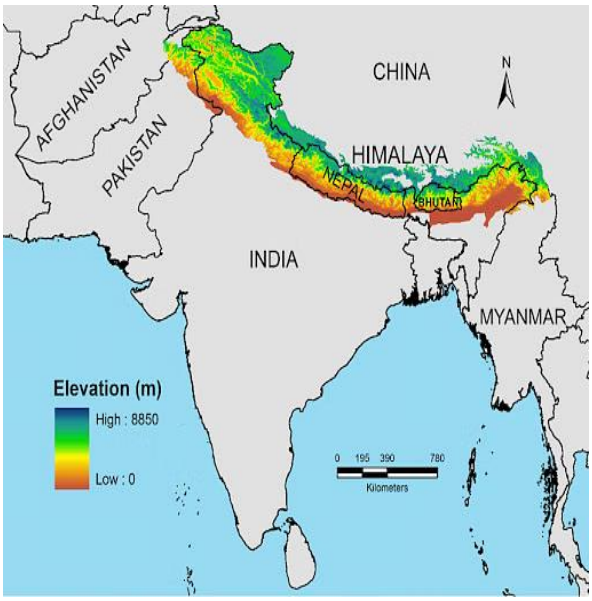

Fig. 1: Himalaya region containing medicinal plant.

In the Himalayan regions of Pakistan, India, China, Nepal, and Nepal, there are twenty medicinal plants that are grown [14]. The purpose of this review is to learn about the antioxidant and phytochemical properties of these plants. *Swertia bimaculate*, *Ficus neriifolia*, *Rubus treutleri*, *Periploca calophylla*, *G. depressa*, *Buddleja napaulensis*, *Habenaria edgeworthii*, *Pyracantha crenulate*, *Roscoea procera*, *Allium*

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rubellum, *Berberis chitria*, and *Capsella bursa-pastoris* are some of the plants that fall into this category. *Artemisia maritima*, *Cinnamomum glanduliferum*, *Cinnamomum distans*, *Juniperus macropoda*, *Origanum vulgare*, *Valeriana jatamansi*, *Polygonatum verticillatum*, *Meconopsis aculeata*, and *Fragaria nubicolais* are the species that are depicted in figure 1 [15,16].

Figure.2: Himalayan region some medicinal plants

II. MEDICINAL PLANT OF HIMALAYAN RANGE

***Swertia bimaculata*:** Since ancient times, species of the genus Swertia, which belongs to the Gentinaceae family, have been utilised in traditional Chinese and Indian medicine in various capacities effects against cancer, diabetes, germs, hepatitis, anthelminths, leishmania, and neuroprotection are only some of the many biological and pharmacological effects that have been demonstrated by members of the genus Swertia [17]. Some of the ailments that have been traditionally treated with these herbs in China include hepatitis, cholecystitis, pneumonia, osteomyelitis, diarrhoea, and scabies. All of these conditions are described below. Iridoids, secoiridoids, xanthones, flavonoids, triterpenoids, and phenolic compounds are the principal components of the Swertia genus, according to all of the information that has been gathered from scientific research [18]. Swertia contains a number of different compounds, including swertiamarine, amarogenitine, balanophonin, oleanolic acid, maslinic acid, and sumaresinolic acid. Additionally, swertia contains swertisin, swertiajaponin, isoorientin, isoscutellarein-8-methyl ether, 8-chrysoeriol, kaempferol, luteolin, quercetin, and β-sitosterol [19,20].

Ficus neriifolia: There are numerous variants of the Moraceae family tree known as *Ficus neriifolia*, which is a widespread fodder tree. These varieties can be found in Nepal, Bhutan, India, China, Indochina, and Myanmar. Between 1400 to 2200 meters in height, it can be found in Nepal during this time period. In traditional medicine, the juice extracted from the bark and stems of this plant was used to treat boils and conjunctivitis for a long time. Among the many different types of compounds that can be found in plants belonging to the genus Ficus are triterpenoids, alkaloids, glycosides, coumarins, anthocyanins, phenolics, saponin, and triterpenoids. There are a great number of chemical components that may be found in *Ficus neriifolia*, including Euphol, Nerifoliol, Taraxerol, B-amyrin, Glut-5-(10)-en-1-one, Cycloartenol, and Neriifolione with many others. Research has resulted in the isolation of a number of phytochemical components from the leaves of *F. neriifolia*. These components include stigmasterol glucoside, prunetin, derrone, and alpinumisoflavone [21].

***Rubus treutleri*:** In China, Bhutan, India, and Nepal, you can find shrubs belonging to the Rosaceae family. These shrubs are called *Rubus treutleri* [22]. It reaches a height of roughly 2 meters and has stalked, alternating leaves that are slightly hairy on both surfaces. Additionally, it has a base that is cordate. The flowers are white in appearance, while the fruits are a scarlet colour. Flowers bloom from June to August, and fruits ripen from September to November. Plants bloom from June to August. Genes can be passed down from one plant to another by the plant's roots, branches, or seeds. For centuries, people in the Tanahun region of Nepal have relied on the roots to alleviate burning sensations in the stomach, urine, feet, and hands for medicinal purposes [23]. Furthermore, *Ficus racemosa*, *Castanopsis indica*, *Poranopsis paniculata*, *Cheilocostus speciosus*, and *Pogostemon benghalensis* are some of the other plant species that are frequently utilised in conjunction with this particular combination. There are a variety of various compounds that are included in the chemical composition of Rubus species, which is quite interesting [24]. Flavonoids such as quercetin and kaempferol-3-0-glucoside, hydrolysable tannins, phenolic acids such as chlorogenic, gallic, ferulic, and caffeic acids, ellagitannins, anthocyanins, terpenoids such as 8-hydroxylinalool, cis-linalool oxide, cosmene, eucalyptol, geranial, geraniol, Grandlure II, Hotrienol, isogeraniol, linalool, glycosides, and waxes are some of the components that are included in this category [25].

***Periploca calophylla*:** As a trailing shrub that is a member of the Apocynaceae family, it can be discovered in Central West China, Nepal, India, Bhutan, and Tibet [26]. In addition to having a lanceolate shape, the long acuminate leaves have a glossy, leathery appearance.

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Flower cymes are fragrant and contain the flowers. In the months of April through May, the flowers are in full bloom, and the months of November through January are when the fruit is ready to be harvested [27]. The plant is propagated through the use of seeds. It helps reduce a wide variety of ailments in Nepal, including bone fractures and muscular discomfort, to name just two of those complications. It is possible to treat the symptoms of traumatic injuries and snakebite by using the stem of the respective plant [28]. Through phytochemical analysis of Periploca species, a number of metabolites, including steroids (periplocin, periplogenin, periplocymarin, and biondianoside A), carbohydrates (cymarose), and other substances, were discovered in the stem of *P. calophylla*. The compound O-acetyl-β-cymaropyranosyl(1 4)O-β-d-cymaropyranosyl(1→4) compoundsThe compound -O-β-d-canaropyranosyl(1→4)(l→4) -O-β-d-cymaropyranosyl esters-O-oleandronic acid-δ-lactone), terpenoids (β-amyrin, ursolic acid, 2α,3β-dihydroxy ursolic acid, α-amyrin acetate, lupeol acetate), phenylpropanoids (sinapic acid, sinapate glucose-1-ester, cleomiscosin A, (+)-syringaresinol-4′-O-β-d-monoglucoside), flavonoids (kaempferol-3-O-α-d-arabinopyranoside, kaempferol-3-O-β-d-glucopyranoside, 3′,4′,5,7-tetrahydroxy-flavanone-2(S)-3′-O-β-d-glucopyranoside), quinones (physcion), and aromatics (vanillic acid, 4-hydroxy-3-methoxyl benzaldehyde, 2,6-dimethoxy-4-hydroxyphenol-1-O-β-d-glucoside) [29,30].

***G. depressa* :** Among the many plant species that are classified under the Gunnera genus, *G. depressa* is one of them. This plant, which is actually a member of the Gunneraceae family, was given its name because of its supernatural aspect [31]. It is possible to discover them in nations such as Nepal, India, and Bhutan, which are situated higher up on the foothills of the Himalayas. This plant is a perennial that grows in a small space and spreads via creeping. Near the ground, the leathery, minuscule leaves come together to create a rosette. These leaves are rounder and smaller than those of other species of Gunnera. Rough and toothed, they maintain a small size and remain close to the ground. There aren't many medical properties, with the exception of those that are digestive and antioxidant in nature. It was discovered that the dried aerial sections of *Gentiana depressa* contain a number of compounds. These compounds include the flavones isoscoparin, 2-glucosyl isovitexin, and 2-glucosyl isoorientin; the iridoid loganin, which was already known; and two new iridoid glucosides, as well as depressine and 3-glucosyl depresteroside. Nepetaside aglucone, Loganic acid, Loganetin, and 4'-m-Hydroxybenzoyl loganin are some of the other chemical components that are present. Specifically, the chemical is a combination of 7-hydroxyfsecologanol and 7-0-(4-O-Glucosyl) coumaroyl-loganic acid respectively [32].

Buddleja napaulensis: Although it is more often known as the "Nepalese butterfly bush," At the same time as it belongs to the Scrophulariaceae family, the *Buddleja napaulensis* is a species that belongs to the Buddleja genus [33]. They are found in the Himalayan areas, which include Nepal, Bhutan, and parts of India, and they live at elevations ranging from 1,500 to 3,000 meters. These kinds of shrubs have the potential to grow to a height of four meters. There are a variety of diseases that have been discovered to be vulnerable to plants that belong to the genus Buddleja [34]. Some examples of medical properties include the ability to alleviate pain, being anti-inflammatory, antibacterial, antipyretic, hypoglycemic, neuroprotective, molluscicidal, and amoebicidal, as well as having antioxidant and antimicrobial properties that are beneficial to eye health [35]. Buddleja napaulensiscontains phytochemicals such as Sesquiterpenes (caryophyllane, humulene,benzofuran skeleton), Triterpenes (glutinol, Lupeol, and ursailc acid), Flavonoids (eriodictyol, glucohesperetin and pyracanthoside), Phenylethanoids, Phenylpropanoids, Lignans, Steroids (glutinol and chondrillasterol, β-sitosterol, stigmasterol, stigmasterol-O-glucoside, β-sitosterol-O-glucoside), iridoidglucosides (methylcatalpol, catalpol, aucubin), phenylpropanoids (isoacteoside and acteoside), a triterpene saponin (mimengoside A), flavonoids (diosmin and linarin) in addition to the free sugars mannitol and sucrose [36].

***Habenaria edgeworthii*:** Within the family Orchidaceae, the species *Habenaria edgeworthii* can be found. In the Himalayan region, which encompasses Nepal, India, Bhutan, and significant areas of China, this plant, which is of a medium size, can be discovered growing in open slopes and scrub at elevations ranging from 1500 to 2500 meters [37]. The plant is able to flourish in both warm and cold settings found on land. The roots of this terrestrial orchid are tuberous, and it can grow to a height of up to 75 centimetres [38]. It can be found in India at elevations ranging from 2500 to 3500 meters in the Himalayan states of Jammu and Kashmir, Himachal Pradesh, and Uttarakhand, which are located in the northern and western regions of the Himalayas. Mussoorie, Jaberkhet, Kyarphulli, Company Garden, Deoban, Tehri-nagtibba, Kharsil, and Har-ki-Dun are some of the places that can be found in the state of Uttarakhand. Pithoraghat, also known as the Tejam Jankhola valley, may be found anywhere in Pauri-Khirsu [39]. Asthma, leprosy, skin diseases, anorexia, worms, emaciation, gout, hyperdypsia, cataplepsy, helminthiasis, general debility, burning sensations, thirst, fever, cough, leprosy, sprains, arthritis, sciatica, insanity, and leg disorders are some of the conditions that can be treated with this substance. The principal phytochemical components of *Habenaria edgeworthii* are stillbenoids, anthraquinones, pyrenes, flavonoids, anthocyanins, lignans, simple benzenoid compounds, terpenoids, steroids, and chroman derivatives. Stillbenoids are also present [40].

Pyracantha crenulate: There is a species of plant known as *Pyracantha crenulata* that is indigenous to the North Western Himalayas. It belongs to the Rosaceae family. Between 900 and 1500 meters in height, it is abundant in hill districts of Uttarakhand, such as Nainital, Pithorgarh,

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Champawat, Chamoli, and Almora, amongst others [41]. These districts were named after the hill regions. There is also a big plant that grows on the foothills of the Himalayas. It can be found in the state of Uttarakhand in Himachal Pradesh, as well as in the northern and eastern states of India and Nepal, at a height ranging from 1600 to 2500 meters [42]. The taxonomy of the plant species *P. crenulata* describes it as a rain-flowering plant species that is most frequently observed on mountainous terrain during the months of June and August. *P. crenulata* can grow to a height of two to five meters at its highest point, and it is covered in thorns and wood. A decision is made located deep into the foothills of the Himalayas. Pine and queue woods, as well as the banks of torrents and streams, are examples of typical habitat configurations. with addition to cultivated ground, open slopes, streambanks, and roadside verges, its habitat consists of places that are covered with shrubs. At the narrow end, the leaves of *P. crenulata* have a smooth surface and a dark green colour. They range in length from 2.5 to 4.0 centimetres and in breadth from 1.0 to 2.2 centimetres [43]. It is the leaves that are used to make herbal tea. Pome fruit, which is a sugar powerhouse, has a vibrant orange-red colouration. Fruit that is both fresh and ripe is the best. There are a number of different chemical compounds, some of which include vitexin, leucocynidine, leucoanthocyanidin, flavanoids, flavonol, kaempferol, glycoside, quercetin, beta-sitosterol, and oligomeric saponins. The results of the quantitative biochemical examination of the leaf extract of P. crenulata revealed the existence of a number of different physicochemical characteristics. These characteristics included carbohydrates, protein, crude sugar, ascorbic acid, fibre, and other components. A number of microelements and macroelements, such as iron, potassium, sodium, calcium, zinc, lithium, copper, manganese, and cobalt, were found to be present in the composition of the elemental compound. In accordance with the findings of the phytochemical research, alkaloids, saponins, glycosides, tannins, and phenols are all present [44].

***Roscoea procera*:** Roscoea is a type of flowering plant that is indigenous to the Himalayas and is a member of the Zingiberaceae family, which is also known as the ginger family [45]. The mountainous regions of the world with elevations ranging from 1,200 to 3,000 meters are the ideal growing conditions for *Roscoea procera*. An average plant is between 30 and 40 centimetres in height [46]. In addition to its anti-inflammatory and antioxidant properties, *Roscoea procera* also possesses antibacterial properties, making it a therapeutic herb. Flavonoids, terpenoids, phenolics, and 3-O- β-D-glucuronopyranoside, 3-hexan-1-ol-β-D-glucuronopyranoside are all components that may be found in rosemary. Additionally, kaempferol, ferulic acid, and syringic acid are all present in rosemary [47].

Allium rubellum: *Allium rubellum* is a wild plant that is not only endemic to the Himalayas but also flourishes at high heights. In addition to garlic, leeks, and onions, it belongs to the allium family and genus, which also includes this particular plant. Among its medicinal applications are the reduction of blood pressure and cholesterol levels, the prevention of the development of cancer, the elimination of bacteria, and the enhancement of the immune system, among other things [48]. The active components of garlic and onion include organosulfur compounds (alliin, allicin, ajoene, allylpropyl disulphide, diallyl trisulfide (DATS), S-allylcysteine (SAC), vinyldithiins, Sallylmercaptocysteine), several enzymes (allinase, peroxidase, myrosinase, catalases, superoxide dismutases, arginases, lipases), flavonoids (allixin), trace elements (germanium and selenium), volatile oil containing sulphur compounds, essential amino acids (arginine, glutamic acid, asparaginic acid, methionine, threonine), lectins (the most abundant proteins in garlic and onion), prostaglandins, fructan, pectin, adenosine, vitamins (B1, B2, B6, C and E), biotin, nicotinic acid, fatty acids, glycolipids and phospholipids. The Persian shallot has a number of different phytochemical components, the most well-known of which are saponins, sapogenins, sulfur-containing compounds (thiosulfinates), and flavonoids like shallomin, quercetin, and kaempferol.a multitude of flavonoids, such as elavonols, which are conjugates of a wide range of quercetin, isorhamnetin, and kaempferol, are included in this category [49,50].

***Berberis chitria*:** The species of Berberis that is indigenous to the Berberis subfamily of its own family. There are a few different names for the same fruit, including Himalayan berries and Indian berries. It falls under the Himalayan regions that are inhabited by the Tibetans, Bhutanese, Indians, and Nepalese regions. It is classified as a shrub due to its golden wood and prickly branches. Tiny berries can be either red or purple in colour, and their blooms have a bright yellow colouration [51]. The high concentration of bioactive compounds, particularly alkaloids, that are found in *Berberis chitria* is one of the reasons for its popularity in the medicinal field. Used as a medicinal treatment for a wide range of illnesses, including infections of the skin and digestive tract, diabetes, cancer, cardiovascular disease, and other conditions. The two compounds that are considered to be the most significant among the several Berberis species are berberine and berbamine. A phytochemical analysis of the crude extract of *B. vulgaris* revealed the presence of phenolic compounds, tannins, and alkaloids. These substances were shown to be present in the extract. Triterpenes such as lupeol and oleanolic acid are extracted from the fruits of the plant. Sterols such as stigmasterol and stigmasterol glucoside are derived from the hexane and ethyl acetate extracts of the plant, respectively. Additionally, three alkaloids, berberamine, palmatine, and berberine, were previously unknown to be present in B. vulgaris. Additionally, it has been demonstrated that the plant contains bisbenzlisoquinolines, such as oxycanthine, in addition to other major alkaloids, such as

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oxyberberine, columbamine, isocorydine, lambertine, and magniflorine. A number of cytoprotective compounds, including (±)-lyoniresinol, cannabisin G, and N-(p-trans-coumaroyl) tyramine, have been obtained from the ethyl acetate extract of *B. vulgaris*. 2,5-bis-(2'-methoxy-5'-methylphenyl)2,'-hydroxy-5'-methylphenyl, and 1,4-bis-furan (17) are the compounds that are in dispute here. In order to separate and identify -butan-l: cdione, the root extract of B. umbellate that was extracted with ethanol was utilised. As a consequence of chromatographic separation of the crude alkaloid component of *B. chitria*, which is an isoquinoline alkaloid, amorphous solid O-methylcorydine-N-oxide was obtained. This was accomplished. In addition, the highly sought isoquinoline alkaloid berbamine can be discovered in B. aristata leaves [52].

***Capsella bursa-pastoris*:** The small herb plant that is commonly referred to as shepherd's purse, also known as *Capsella bursa-pastoris*, is a member of the Brassicaceae family, which also contains mustard and cabbage [53]. At the beginning of spring, when it is bearing its distinctive green fruits that are flat and heart-shaped, this plant really comes into its own. These fruits are carried on stalks that grow from the inflorescence. Clusters of white blooms with four petals can be found at the very tips of the stems. The seeds are surrounded by a cluster of tiny stem leaves that are shaped like an arrow and clasp together. When plants reach a height of 45 centimetres (18 inches), they produce a rosette consisting of basal leaves that have been sliced very finely or are nearly complete [54]. There are a wide variety of applications for this versatile medicinal plant, including the treatment of skin inflammation, the prevention of bleeding, the treatment of high blood pressure, the healing of wounds, the treatment of postpartum haemorrhage, and the treatment of ageing. Flavonoids and polypeptides were also present in the aerial sections of the plant, in addition to choline, acetylcholine, histamine, and tyramine [55]. Not only did the plant include minerals and vitamins, but it also contained ascorbic acid, proteins, linoleic acid, and ρ3 polyunsaturated fatty acid. The oils extracted from the seeds and roots of Capsella bursa-pastoris included a variety of fatty acids, including azelaic acid, palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, arachidonic acid, and 11-eikozenoic acid, respectively. Cholesterol, campesterol, βsitosterol, cholest-5-en-3-one, ergosta-4,6,8, lupeol, stigmasta-3,5-dien-7-one, stigmasta4-en-3-one, and other phytosterols that have not yet been described were discovered in the phytosterol compound of *C. bursa-pastoris*. Flavonoids were extracted from the complete plant of *Capsella bursa-pastoris* utilising the full plant. Tricine, kaempferol, quercetin, kaempferol-7-O-α-L- rhamnopyranoside, quercetin-3-O-β-D-glucopyranoside, quercetin-6-C-β-D-glucopyranoside, quercetin-3-O-β-Dglucopyranosyl-7-O-α-L-rhamnopyranopyranoside, and kaempferol-3-O-rutinoside were discovered throughout our investigation. In addition to sulforaphane, *Capsella bursa-pastoris* was discovered to contain another isothiocyanate compound [56].

Artemisia maritima: In order to reduce indigestion and get rid of worms in the intestines, several cultures in the Himalayas make use of the herb *Artemisia maritima*, which is a member of the Asteraceae family. In the Malari (Garhwal area, India) sample, it was discovered that the essential oils of *A. maritima* included high amounts of -thujone (63.3%), sabinene (7.8%), and 1,8-cineole (6.5%) [57]. Additionally, the Himachal Pradesh and Chamoli (Garhwal region, India) samples contained high concentrations of 1,8-cineole and chrystanthenone. The most prevalent monoterpenoid, camphor, was found in the essential oil sample that was taken from Lahaul-Spiti, which is located in the state of Himachal Pradesh in India [58]. The sample was examined to establish whether or not it possessed antibacterial properties against *S. aureus*, *E. coli*, *S. abony*, *P. aeruginosa*, and *Candida albicans*; nevertheless, it was found to be inert towards these bacteria. Camphor, which had a concentration of 20.3%, and 1,8-cineole, which had a concentration of 41.1%, were both found in Pakistani commercial *A. maritima* oil simultaneously [59]. It is likely that the high levels of thujone found in certain of the essential oils of *A. maritima*, which have been demonstrated to be effective as an anthelmintic, are responsible for the ethnopharmacological usage of this plant to eradicate infestations of intestinal parasites. The molecule, on the other hand, is a potent neurotoxic agent that also acts as a GABA-gated chloride channel modulator. On the other hand, camphor is not effective against parasites; however, it is hazardous to human health and, if consumed, can cause convulsions. It has been demonstrated that 1,8-cineole inhibits castor oil-induced diarrhoea in rats, prevents ethanol-induced gastric injury in rats, and attenuates trinitrobenzene sulfonic acid-induced colitis in rats. This suggests that 1,8-cineole may be an essential component in the traditional use of herbal remedies that contain 1,8-cineole for the treatment of gastrointestinal issues [60].

C. glanduliferum: One type of flowering plant that is a member of the Fabaceae family is called Glanduar Caragana, which is also known as *C. glanduliferum*. It is possible for the deciduous shrub to grow to a height of 1.5 to 3 meters [61]. The locals who live in the Dolakha district of Nepal utilise a paste that is prepared from the roots of *C. glanduliferum* to treat any wounds or toothaches they may be experiencing. Because of its fragrant, stimulating, and anti-inflammatory characteristics, the leaves of the *C. glanduliferum* plant are widely used as a treatment for respiratory conditions in the northern region of India. Research has demonstrated that a leaf oil sample from northern India, which contains a high concentration of 1,8-cineole (41.4%), -pinene (20.3%), and -terpineol (9.4%), has the ability to inhibit the growth of Gram-positive bacteria (Micrococcus luteus) as well as Gram-negative bacteria (*Escherichia coli*, *Pseudomonas aeruginosa*, and

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Aeromonas salmonicida) [62]. The presence of a high concentration of 1,8-cineole is one of the possible explanations for the effectiveness of this remedy against coughs and colds. In addition to its mucolytic and spasmolytic qualities, 1,8-cineole has been shown to have beneficial effects in clinical trials for the treatment of inflammatory airway diseases such as asthma and chronic obstructive pulmonary disease (COPD). It is highly improbable that 1,8-cineole is the only antibacterial component of *C. glanduliferum* leaf oil; rather, it is feasible that 1,8-cineole and other minor components interact together to affect the antibacterial activities of the oil. There was no investigation into the biological activity of this oil; however, it has a high concentration of (E)-nerolidol (52.2%), and it has been claimed to be a chemotype of *C. glanduliferum* [63].

***C. distans*:** There are several species that belong to the Caragana genus, which is a part of the Fabaceae family. Some of these species are *Juniperus macropoda*, *Valeriana jatamansi*, *Origanum vulgare*, and *C. distans* [64]. The plants of this little shrub, which has pinnate leaves with several pairs of leaflets, produce yellow flowers that blossom from their stems. The components of the essential oil that are found in *C. distans* can vary according on the growth conditions and the place that is being considered. Therefore, for example, the essential oil that was obtained from Munsyari in Uttarakhand had 35.0% citral (neral and geranial), 15.0% geranyl acetate, and 9.5% geraniol components [65]. Additionally, the essential oil that was generated in Pantnagar, Uttarakhand, consisted of geranyl acetate (19.5%), geraniol (14.8%), neral (16.9%), and geranial (22.8%) as its primary constituents. On the other hand, the essential oil of C. distans var. Loharkhet included a significant concentration of the sesquiterpenoids eudesmanediol (34.4%) and 5-epi-7-epi--eudesmol (11.2%) [66]. This is in contrast to the oil from Nainital (Uttarakhand), which was predominantly consisted of -oxobisabolene (68%). The presence of particular marker compounds in the oils of C. distans allowed Mathela and her colleagues to identify four distinct chemotypes. These chemotypes are as follows: oxobisabolene (chemotype I), citral, geraniol, and geranyl acetate (chemotype II), piperitone, limonene, and eudesmanediol (chemotype III), and sesquiterpene alcohols (chemotype IV) [67].

Juniperus macropoda: There is a species of Juniper that is indigenous to the high-altitude Himalayan regions of Afghanistan, Pakistan, India, Bhutan, Nepal, and a piece of Tibet. This species is called *Juniperus macropoda*. There are a few names for this species, including Himalayan pencil Cedar and Large-footed Juniper. In Himachal Pradesh, the berries of the Juniperus macropoda tree are used to treat ulcers by applying them locally [68]. Additionally, the resin of the tree is consumed orally to treat indigestion, impotence, diarrhoea, cough, chest colds, and colic. Tibet and the Ladakh region of northern Jammu and Kashmir are two of the most popular places to get incense that is created from the needles. Tibetans use the needles to treat kidney conditions, Lamas take tablets made of wood to treat menstrual cycle irregularities (such as amenorrhoea, dysmenorrhea, and other similar conditions), and Tibetans in Ladakh take a combination of berries from J. macropoda and other plants to treat urinary and kidney issues. It has been discovered that the essential oils that can be obtained in the leaves of *J. macropoda* have a very different chemical composition. Sabinene accounts for 27.5% of the total, cedrol accounts for 14.1%, and terpinen-4-ol accounts for 9.5% of the total in a leaf oil sample that was taken from Chamba, Himachal Pradesh. The effectiveness of this oil as a larvicidal and antifungal agent against mosquitoes was demonstrated. It was found that 42.5% of the oil in a sample of Uttarakhandi aleaf oil taken from Hindokhal included trans-sabinene hydrate, 8.8% contained cubebene, and 7.9% contained thujone. In a different sample taken from Mussorie in Uttarakhand, the ratio was found to be 22.6% biformene, 7.7% sabinene, and 5.8% thujone [69].

Origanum vulgare: The plant known as *Origanum vulgare*, which belongs to the Lamiaceae family of mints, is commonly referred to as "oregano" in Europe and "Himalayan marjoram" or "Indianoregano" in India. It is a small and bushy plant that can grow to a height of 30–80 centimetres [70]. This species can only be found in the northwest Himalaya, namely in the Kumaon and Garhwal districts of Uttarakhand Himalaya. Its elevations range from 600 to 4000 meters, making it a unique native to the region. Five of the several chemotypes that O. vulgare can produce are as follows: (1)-terpinene/thymol, (2) thymol/ocimene, (3) thymol/-terpinene, (4)-terpinene/carvacrol, (5) carvacrol/-terpinene, and (6) linalool. Cymyl-type O. vulgare monoterpenes are rich in p-cymene, thymol, and carvacrol. This particular type of O. vulgare monoterpene is one of the three types [71]. The second kind is known as the acyclic-type, and it is predominantly found in derivatives of myrcene, ocimene, linalool, and linalyl chemicals. A sabinyl-type organism is the third type. Some of the traditional applications of *O. vulgare* include the treatment of bronchial and pulmonary disorders, such as coughs and colds [72]. This use has been around for a long time. The chemotypes of the plant that are abundant in thymol and carvacrol possess a variety of pharmacological properties that provide support to this application [73]. These features include antibacterial, antitussive, antihistamine, and a considerable number of other properties. It has been proven that the monoterpenoid alcohols linalool, terpinen-4-ol, and terpineol, as well as the sesquiterpenoids caryophyllene, humulene, and germacrene D, possess antibacterial characteristics. This is in accordance with the potential actions and applications of the other chemotypes of *O. vulgare* [74].

***Valeriana jatamansi*:** *Valeriana jatamansi*, which belongs to the family of valerianaceae, is utilised extensively in traditional medical practices such as Ayurveda, Unani, and those that are considered to be folk

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medicines. Besides that, it is sometimes referred to as Tagar or Indaian Valerian [75]. China, Bhutan, Nepal, and India are the countries that are located in the Himalayan region and are the original habitats of these plants. It has been used for a long time in Ayurvedic and Unani medicine in India. *Valeriana jatamansi* Jones, also known as *Valeriana wallichii* DC., is claimed to have a sedative impact on nervous unrest, tension, neuralgia, and skin illnesses. Additionally, it is said to have a sedative effect on insanity, epilepsy, and snake bites [76]. During the course of the literature study, it was discovered that *V. jatamansi* contains flavonoid glycosides, iridoids, and lignans altogether. Extracts of V. jatamansi have been shown to have significant anti-inflammatory, anti-anxiety, anti-diarrheal, and bronchodilatory properties, and this has been demonstrated through scientific research. The plant has also been shown to have antileishmanial and cytotoxic properties, according to evidence obtained through in vitro testing [77]. As a result of the presence of antibacterial and antifungal activities in the essential oil of *V. jatamansi*, it is effective against a wide range of fungal infections that can affect both plants and people. Based on the chemical compositions of the essential oils extracted from the root and rhizome, it has been determined that V. jatamansi possesses six distinct chemical chemotypes. (a) a chemotype that is abundant in maaliol (approximately forty to sixty percent), (b) a chemotype that is abundant in patchouli alcohol (more than forty percent), (c) a chemotype that is abundant in patchouli alcohol and -bulnesene, (d) a chemotype that is abundant in patchouli alcohol and viridiflorol, (e) a chemotype that is abundant in seychellene, and (f) a chemotype that is abundant in kanokonyl acetate [78]. Melaleate, valeracetate, bornyl acetate, and cuparene were the principal components of the root oil of *V. himalayana* that was gathered from the Talle valley in Arunachal Pradesh. Arunachal Pradesh is located in the subcontinent of India. Parts of two distinct chemotypes were found in the roots of *Valeriana hardwickii* var. arnotiana: Valeracetate, 8-epikessyl glycol diacetete, -kessyl acetate, and malliol were the marker chemicals in chemotype I, which was obtained from Milam glacier at an altitude of 3500 m; kessanyl acetate and maaliol were the key elements in chemotype II, which was collected from Vishnu Prayag. Verticillium hardwickii var. hardwickii is the source of the sesquiterpene epoxysesquithujene, which was isolated from the plant. Valeranone and patchouli alcohol were the two major components that were found in the root oil of *V. pyrolaefolia* [79].

Polygonatum verticillatum: *Polygonatum verticillatum*, often known as BMeda, is a perennial rhizomatous herb that belongs to the family Asparagaceae, which was once known as the Liliaceae. It is native to the high Himalayan regions to elevations of up to 4,000 meters above sea level [80]. There are eight different kinds of Astavarga plants, and this particular one is well-known for its capacity to increase vitality. It is the rhizome of the species that is contained in Chyavanprash, as well as in other aphrodisiac ayurvedic formulations such as Dhanwantharam Kashayam and Dhanwantharam Kuzhambu. The therapeutic benefits of the plant are attributed to secondary metabolites, which include saponins, alkaloids, phytohormones, and flavonoids, among others. The protection of biomolecules from the molecular damage that is associated with ageing is the mechanism by which these active components extend the lifespan of the organism [81]. These three kinds of steroidal saponins, which are present in the Polygonatum genus, are the major components that are responsible for the psychedelic effects. All of the glucose, galactose, xylose, rhamnose, and fucose that make up the glycosyl moiety of polygonatum saponin are responsible for the majority of the molecular variation that it possesses. Polygonatum mill contains a variety of flavonoids, the most frequent of which are flavones [82]. Other flavonoids that are present in polygonatum mill include dihydroflavonoids, isoflavones, and homoisoflavonoids. Each of the three phytochemical quinones that may be discovered in Polygonatum verticillatum are emodin-8-O-β-D-glucopyranoside, polygonaquinone A, and polygonaquinone B. The polysaccharide found in plants that belong to the Polygonatum genus is one of the most important components of these plants. Galactomannan galactose has a total of five different types of polysaccharides: two types of neutral polysaccharides (PSB-2A and PSB-1B), two types of acid polysaccharides (PSW-2A-1 and PSW-3A-1), two types of glycoproteins (PSW-4A and PSW-5B), and one kind of neutral galactose (PSW-1B-b) [83].

Meconopsis aculeata: *A. aculeatum*, often known as *Ascophyllum Royle* is a plant that is native to the Himalayas and belongs to the Papaveraceae family. It is commonly referred to as the "Himalayan poppy," "Blue poppy," or "Achatsarmum." At the same time, it is classified as a "Endangered" plant. The prickly herb with blue flowers can be found growing in alpine regions, among stones, as well as in light forests with wet soils and gaps in rocks [84]. Due to the fact that it is a hermaphrodite species, it has been venerated for a long time as an essential component in traditional medicine for a wide range of applications. These applications include the alleviation of rheumatic symptoms, relief from fever, analgesic, narcotic, and bone (especially rib) discomfort. The blossoms of this species have long been used by the indigenous people of the Chamba and Lahaul-Spiti districts in Himachal Pradesh, as well as the Bageshwar region in Uttarakhand, to ease the symptoms of asthma, discomfort, fever, and cough [85]. There are several extracts of it that contain phytoconstituents such as alkaloids, phenolics, tannins, cardiac glycosides, flavonoids, saponins, steroids, triterpenoids, carbohydrates, proteins, amino acids, phytosterols, and phlorotannins. These extracts come from a variety of solvents, including hexane, ethyl acetate, methanol, and water. M. aculeata has a number of components that are

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relevant from a pharmacological standpoint. Among these components are the terpenoids, which have powerful anti-inflammatory, anti-cancer, anti-malarial, anti-viral, and antibacterial properties [86].

Fragaria nubicola: Wild strawberry, Himalayan strawberry, or *Fragaria nubicolais* are some of the common names for this type of strawberry that is native to the Himalayan highlands. There are also other names for this species [87]. The Himalayan regions of China, Bhutan, Nepal, and India are the natural habitats of this floral species, which belongs to the Rosaceae family.It is found growing in open forests, grassland, and along the slopes of the Himalayan mountains, and its typical habitats range in height from 1,200 to 3,500 meters [88]. Even though birds do not consume them in large quantities, the role that these wild edibles play in the environment is quite important, and as a result, we cannot disregard the value that they possess [89]. Consuming these wild edibles, whether raw or cooked, can help reduce the likelihood of developing neurological and degenerative problems. This is due to the fact that these wild edibles have a high concentration of vitamins, minerals, polyphenolic agents, antioxidants, and other helpful components. The sustainable utilisation of berries has a significant impact on the nation's food security [90]. To alleviate hunger and improve the economic status of local residents, their processed forms, such as juice, jam, sauce, and other similar products, have the potential to be of great assistance. Tannins, flavonoids, phenolic acid, proanthocynidins, flavonols, ellagic acid glycosides, and benzyl derivatives are some of the nutrients that are abundant in the fruits of this species. this fruits also have a good flavour and are visually appealing [91].

Table 1: Most common used secondary metabolites found in plants

S.N	Plant	Alkaloids	Glycoside	Flavonoid	Poly-phenol	Terpenoids	Tannins	References
1	*Swertia bimaculate*	+	_	+	+	_	+	[17-20]
2	*Ficus neriifolia*	+	_	+	+	+	+	[21]
3	*Rubus treutleri*	+	+	+	+	+	+	[22-25]
4	*Periploca calophylla*	+	+	+	+	+	+	[26-30]
5	*G. depressa*	+	_	+	_	_	_	[31,32]
6	*Buddleja napaulensis*	_	+	+	+	+	_	[33-36]
7	*Habenaria edgeworthii*	+	+	+	+	+	+	[37-40]
8	*Roscoea procera*	+	_	+	+	+	+	[45-47]
9	*Allium rubellum*	+	_	_	+	+	_	[48-50]
10	*Berberis chitria*	+	+	+	+	+	+	[51,52]
11	*Capsella bursa-pastoris*	+	_	+	+	_	+	[53-56]
12	*Artemisia maritima*	_	_	+	+	+	+	[57-60]
13	*C. glanduliferum*	+	_	+	_	+	+	[61-63]
14	*C. distans*	+	_	+	+	+	+	[64-67]
15	*Juniperus macropoda*	+	_	+	_	+	+	[68,69]
16	*Origanum vulgare*	_	_	+	+	+	+	[70-74]
17	*Valeriana jatamansi*	+	_	+	_	+	_	[75-79]
18	*Polygonatum verticillatum*	+	_	+	+	_	_	[80-83]
19	*Meconopsis aculeata*	+	+	+	_	_	_	[84-86]
20	*Fragaria nubicola*	_	_	_	+	_	+	[87-91]

III. ANTIOXIDANT ANALYSIS OF THE HIMALAYAN MEDICINAL PLANT

Through the use of antioxidant analysis, one is able to determine the level of antioxidant activity present in a sample, such as an extract from a food or plant. Analysis of antioxidants can be carried out in a variety of ways, including the following: Spectrophotometry is a method that is widely used since it is not only rapid and accurate but also easily repeatable, affordable, and quick [92]. In the realm of spectrophotometric methods, such examples include ferric reducing antioxidant power

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(FRAP) assays, 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays, and 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assays. There are a variety of other techniques that can be utilised to rapidly screen extracts for active compounds [93]. These techniques include electrochemical, chemi luminescent, electron spin resonance, capillary electrophoresis, nuclear magnetic resonance, near infrared spectroscopy, mass spectrometry, and high-performance liquid chromatography (HPLC) with DPPH and/or ABTS assays [94]. After applying this formula, we were able to ascertain the radical scavenging activity, which is as follows:

% Radical scavenging activity = [(Control abs sample abs)/Control abs)] x100

One of the most essential functions of antioxidants is to reduce oxidative stress, which is a type of stress that can cause damage to biological components. Many people are of the opinion that the curative effects of medicinal plants can be attributed to the antioxidant capabilities of these plants, specifically the polyphenolic compounds and antioxidant vitamins [95]. A lower IC_{50} value suggests that the plant has a higher radical scavenging activity than a larger value. In terms of its antioxidant properties, the plant extract that displayed the lowest IC50 value was superior to the other extracts. Antioxidants, which act as modulators of cellular signalling systems, shield the organism from the damage that is caused by oxidative stress that is triggered by environmental free radicals. Table 2 presents the IC_{50} values that were determined by the antioxidant DDPH tests conducted on twenty different medicinal plants that are native to the Himalayas. In the course of the analyses, a wide range of solvents and common compounds were utilized [96].

S.N	Plant	IC50 Value	Solvents	Plant part	References
1	*Swertia bimaculate*	4.80µg/ml	Methanol	leaf	[97]
2	*Ficus neriifolia*	233.36µg/mL	Ethanol	Leaves	[98]
3	*Rubus treutleri*	105.4 µg/mL	Aqueous	Stem	[98]
4	*Periploca calophylla*	94.36µg/mL	Ethanol	Aerial part	[99]
5	*G. depressa*	183.193µg/ml	Methanol	Whole plant	[100]
6	*Buddleja napaulensis*	68.27 µg/mL	Methanol	Fruit	[101]
7	*Habenaria edgeworthii*	76.89 µg/ml	Ethanol	Leaves	[102]
8	*Roscoea procera*	101.37 µg/ml	ethanol	leaves	[103]
9	*Allium rubellum*	6.450µg/ml	Methanol	Whole plant	[104]
10	*Berberis chitria*	9.616µg/ml	Methanol	Leaves	[105]
11	*Capsella bursa-pastoris*	235.37 µg/ml	Chloroform	Seed	[106]
12	*Artemisia maritima*	78.09µg/ml	Methanol	leaves	[107]
13	*C. glanduliferum*	138.2µg/ml	Methanol	leaf	[110]
14	*C. distans*	113.19 µg/ml	Methanol	Whole plant	[108]
15	*Juniperus macropoda*	138.2µg/ml	Methanol	Leaf	[109]
16	*Origanum vulgare*	43.7µg/ml	methanol	Whole plant	[111]
17	*Valeriana jatamansi*	78µg/ml	Methanol	Root	[112]
18	*Polygonatum verticillatum*	9.59µg/ml	Methanol	Whole plant	[113]
19	*Meconopsis aculeata*	2.35µg/ml	Methanol	Flower	[114]
20	*Fragaria nubicola*is	3.82µg/ml	Methanol	Fruit	[115]

IV. CONCLUSION

20 different plants were discovered to have high levels of phytochemicals, including total polyphenols, flavanoids, alkaloids, glycosides, tannins, terpenoids, and other phytochemicals, according to the findings of this study, which utilised a wide range of solvents and plant components. When it came to scavenging free radicals, the plants demonstrated a high level of antioxidant activity. In spite of the fact that herbal medicines made from plant extracts are becoming increasingly popular for the treatment of a wide variety of clinical conditions, there is a dearth of information regarding the mechanisms of action of these medicines. It is possible for the lengthy history of traditional medicine's dependence on plants for therapeutic purposes to serve as a source of inspiration for research into novel biological substances and the development of novel medications. In order to evaluate the hepatoprotective properties, efficacy, and safety of all of the medicinal plants that have been asserted, it is without a doubt necessary to conduct additional phytochemical, pharmacological, and clinical investigations. The use of medicinal plants has the potential to result in the development of a wide variety of innovative pharmaceutical, nutraceutical, and healthcare product compositions. The medicinal plants contain a wide variety of phytochemicals that have pharmacological activity. These phytochemicals have

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been used in the treatment of a variety of disorders throughout history. Medicinal plant species are used to cure a wide range of conditions, including major illnesses like asthma and jaundice as well as minor ailments like cough, cold, fever, and skin infections.

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