**Advances in Bioresearch**
Adv. Biores., Vol 17 (1) January 2026: 273-280

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.17.1.273280

Advances in Bioresearch

## REVIEW ARTICLE

# Bioactive Essential Oils of *Prinsepia utilis*: Insights into Their Biological and Pharmacological Properties – A Review

**Rahul[a], R S Sajwan[a*], Ankit S Bartwal[b], Tanisha Debnath[c]**
[a]Department of Chemistry, School of Applied and Life Sciences, Uttaranchal University, Dehradun, Uttarakhand -248007
[b]Department of Chemistry, HNB Garhwal University, Uttarakhand, India-249199
[c]Department of Biotechnology, School of Applied and Life Sciences, Uttaranchal University, Dehradun, Uttarakhand -248007
*Corresponding Author- rohit.chem72@gmail.com

**ABSTRACT**
*Uttarakhand is renowned for its diverse array of therapeutic vegetation that has played a crucial part in supporting tribal communities related to the Himalayas. This comprehensive review provides a brief overview of various organic actions of Prinsepia utilis, a member of the Rosaceae family, which can be found both in the wild and in cultivation. Prinsepia utilis Royle is a deciduous shrub characterized by thorny foliage and is Indigenous to the Himalayan region. Historically, this plant's leaves, roots, and seeds have been used to cure inflammatory processes, pain from rheumatism, stiffness in the joints, and arthritis. Extensive studies have thoroughly investigated the essential oils extracted from various parts of the Prinsepia utilis plant, including leaves, stems, roots, seeds, and fruits. The chemical composition analysis unveiled a diverse array of bioactive compounds, notably terpenes, phenolics, and alkaloids. The studies reviewed thoroughly looked at the effects of the oils on living organisms. These effects include their ability to prevent cell damage, fight against microbes, reduce inflammation, combat cancer, and repel insects. The results strongly indicate that there are significant variations in biological activities depending on the plant part, extraction method, and oil composition.*
***Keywords***-*: Prinsepia utilis, essential oils, biological activities.*

Received 24.09.2025 Revised 01.10.2025 Accepted 18.01.2026

**How to cite this article:**
Rahul, R S Sajwan, Ankit S B, Tanisha D. Bioactive Essential Oils of *Prinsepia utilis*: Insights into Their Biological and Pharmacological Properties – A Review. Adv. Biores. Vol 17 [1] January 2026. 273-280

## INTRODUCTION

The species of *Prinsepia utilis* (from the Family: *Rosaceae*) consists of four variety of species: *Prinsepia utilis Royle*, *Prinsepia scandens Hayata*, Prinsepia *uniflora Batal*, and *Prinsepia sine*nsis Oliv. Hence, the *Prinsepia utilis* habitually known as Himalayan Cherry. This plant is commonly called Bhekal, Bekhali, Bekoi, Bhekhnu, and Jhatlu in the native region. These species are found in regions of India. Further countries where we can find these plant variants are Bangladesh, Taiwan, and China. Usually, these plants are grown in undeveloped lands near brooks and in bushes and are at an altitude of 1,000 to 3,000 meters above sea level in China. Not only in China, but these plants are also naturally found at these parameters and need cold places to grow better primarily in the provinces of Yunnan, Sichuan, and Tibet [1]. Therefore, this plant is widely grown across Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Meghalaya and Sikkim. This plant variant is domestically pleasant and moderate to Asia, the species thrives in diverse habitats, particularly on slopes outside wooded areas. This includes environments ranging from steep, rocky cliffs in mountainous regions to gentle hills, nearly flat ground in valleys.

Various parts of *Prinsepia utilis*, counting the seeds, the leaves, and the origins, have been exploited in Chinese and Indian traditional medicine to cure several diseases like skin viruses, diarrhea, intestinal aches, inflammation, leprosy, rheumatism, and fatigue-related pain. It is also used to treat fractures, arthritis, bone disorders, and joint pain. Additionally, the plant shows potential efficacy in addressing atherosclerosis and high blood pressure [2]. Research, which was based on the chemistry of unlike

portions of *Prinsepia utilis* has been ongoing since 1942, isolating many complexes from several modules, including terpenes and terpenoids, phenolic acids, anthocyanins, flavonoids, fatty acids, γ-hydroxynitrile glucosides, lignans, and sterols. Beyond its traditional uses, the remedial importance of *Prinsepia utilis* is scientifically recognized through numerous studies [3]. These studies demonstrate that various parts of the plant exhibit a range of organic actions that contain antioxidant, hypoglycemic, α-glucosidase inhibitory, cytotoxic, anti-inflammatory, immunosuppressive, antibacterial, and lipase inhibitory effects, among others, which will be explored further in this review [4].

Despite extensive studies about old-style uses, phytoconstituents, also organic actions, nearby leftovers a deficiency of an inclusive record on *Prinsepia utilis* in the academic texts and research. This analysis objectives to report this opening by studying the existing information on the characteristics of *Prinsepia utilis* [3].

**Fig. 1** Image showing the fruit of *Prinsepia utilis*

**Methods of essential oil extraction**

For many years, essential oil has been used in Chinese and Indian traditional medicine to treat a variety of illnesses, such as leprosy, inflammation, and skin conditions. Many writers have described using various components of vegetation to heal different diseases. *Prinsepia utilis* seed and root extracts are used to cure stomachaches and diarrhea [5].

**Maceration**

Maceration is a process that involves soaking coarse powders of natural materials at room temperature or with slight heating in a suitable solvent. This technique enables extraction by permitting the active components to permeate into the solvent. Heat-sensitive natural ingredients having high concentration of gum, pectin, mucilage and starch can be extracted exceptionally well by this process [6]. The factors affecting the efficiency of maceration includes the impregnation period, leaching solvent, material-liquid ratio, and raw material particle size [7]. Phenolic chemicals are recovered from Hazelnut shells by going through various techniques such as high-power ultrasound, ultrasonic baths, and maceration. Among these various techniques, Maceration is observed to be a straightforward and efficient technique for the removal of active ingredients but time consuming and less quantity of production stands as its drawback.

**Percolation**

Percolation method is dynamic, effectively utilizes the solvent and ensures full leaching of the active components, with direct collection of the leachates. Percolation extraction can be carried out at room temperature, thus considered as a calm technique which is well-suited for materials that are susceptible to heat. The drawbacks of this separation method include the lengthy extraction procedure and the significant volumes of solvent needed [8]. Powder size, extraction duration, flow rate, solvent composition, and solvent dose are some of the factors that affect the process. This technique is frequently casted with varying amounts of white wine or ethanol as solvents, making it necessary to prevent the loss of volatile compounds [9].

**Decoction**

The process of decoction includes space heating and sweltering natural ingredients unpolished residue in liquid for a certain amount of time. Water is used as a solvent to extract natural substances while

employing the decoction procedure. Even though it works fine for extraction, decoction is not recommended for ingredients that contain a lot of starch, mucilaginous ingredients, volatile ingredients, or chemicals that are heat-sensitive and may break down fast. This method is mostly employed in Chinese medicine clinics. Also, several studies show that the decoction extract has durable antifungal and antioxidant qualities, which are related to its high phenolic component concentration [10]. Decoction can only extract natural substances with a greater liquid solubility, which is an obvious disadvantage. Additionally, some carotenoids were degraded due to the high temperatures used during decoction.

**Extraction of Reflux**

The technique known as reflux extraction utilizes volatile biological diluters to separate ingredients from uncooked sources, such as ethanol. In this process, the removed liquid is impassioned and refined, allowing the unpredictable solvent to condense & flow back into the extraction ship. This cycle continues, enabling repeated soaking of the raw materials until the active components are fully extracted. This method improves the extraction rate while reducing the amount of solvent used. However, it cannot be used to extract nutrients that are sensitive to temperature, as a prolonged central heating period can cause damage. The material-to-liquid ratio, extraction duration, and intensity of the natural solvents employed are the primary determinants of the reflux extraction procedure [11].

**Soxhlet Extraction**

The Soxhlet method of extraction, also known for its constant backflow extraction process, uses solution reflux and the siphon concept to remove solid components with every procedure using solely solvent. Compared to conventional reflux extraction, this technique uses a lesser solvent & has greater effectiveness in extraction. It successfully tackles the disadvantages of reflux in the process of extraction, such as the requirement for several reflux cycles and high solvent use. Components harmed by heating are unable to employ this technique. Oils and phenolic chemicals are often extracted by the method of Soxhlet extraction. According to the findings, a greater harvest was obtained with an extraction period of two hours, a feed-to-solvent ratio of 1:20 g/mL, and a level of ethanol of 60% v/v. [12].

**Distillation via Steam**

The primary use of distillation by steam is to remove unstable ingredients, particularly aromatic oils, from unstable compounds, unable to dissolve, and do not degrade when steam distilled. Therefore, a removal process includes releasing the elements that are unstable derived from unprocessed ingredients. This is done by first crushing and soaking the materials, followed by steam distillation, where the components are collected in sheets following evaporation. While distillation via steam uses a modest apparatus and has straightforward operative stages, the high temperatures throughout the procedure can destroy thermally inert elements found in indispensable emollients. [13]. Several factors impact the extraction of volatile oils, primarily related to the herbs themselves, such as humidity gratified, element dimensions, and source. Hydro distillation has been shown to achieve higher yields compared to steam distillation [14].

**CHEMICAL CONSTITUENT OF *Prinsepia utilis***

Indispensable emollients are made up of a variety of specialized assemblies found in plants, which can vary widely in quantity and properties. They start in the cytoplasm of some plant discharges, such as secretory hairs, epidermal cells, and internal secretory cells. These intricate emollient compositions contain around 300 different compounds [15]. Unstable mixtures can be categorized into biological modules: alcohols, ethers, oxides, aldehydes, ketones, esters, amines, amides, phenols, heterocycles, and terpenes. That is significant to emphasize the components of indispensable emollients that are predominantly derived from the vast terpene family. Indispensable emollients are complex mixtures mainly composed of terpenes and oxygenated compounds, which contain a variety of functionalized results given in Table 1. Understanding their chemical ingredients is vital for raising their inimitable assets and smells [16].

**Table 1. Chemical constituents in *Prinsepia utilis* and their biological activity.**

| Compounds | Constituents | Plant Part | Activity | Reference |
|---|---|---|---|---|
| **Terpenoids** | **Hemiterpenoids** (Utililactone, Epiutililactone) | Leaves | Anti-oxidant activity, Osteoprotective effect | [17] |
| | **Monoterpenoids** (Limonene, α-terpineol) | Leaves | Anti-oxidant activity, Osteoprotective effect | [18] |
| | **Triterpenoids** (Ursolic Acid, Maslinic Acid, Pomolic Acid) | Aerial Parts, Leaves | Immunosuppressive Effect, Cytotoxic activity | [17] |
| **phenolics** | **Phenolic Acid** (Gallic Acid, Vanillic Acid, Caffeic Acid) | Fruits, Oil residue | Inhibition of Intracellular ROS, Enzymatic assays | [19,20] |
| | **Anthocyanins** (Cynidin-3-O-glucoside, Peonidin-3-O-rutinoside) | Fruits | Inhibition of Intracellular ROS, Enzymatic assays | [19] |
| | **Flavonoids** (Catechin, Rutin, Isoochaftoside) | Fruits, Seeds, stem | Inhibition of Intracellular ROS, Hypoglycemic Activity, Enzymatic assays | [19,21] |
| **Fatty acids** | Palmitic acid, Myristic acid, Oleic acid, Erucic acid, Arachidic acid, Methyl tetra decanoate) | Seeds | Antibacterial activity, Anti-oxidant activity | [20,22] |
| **γ-hydroxynitrile glucosides** | Prinsepicyanoside A,B,C,D,E,F,G,H,I | Seeds residue | Antibacterial activity | [23,24] |
| **Other Classes** | **Alkane** (Heneicosane, Hexacosane, Pentacosane) | Seed oil | Anti-aging activity, Sun protection assay, Anti-oxidant activity | [20] |
| | **Alcohols** (2-dodacanol, Tetratriacontanol) | Leaves | Anti-oxidant activity, Osteoprotective effect | [18] |
| | **Ketones** (2-undeca) | Leave, Seeds | Anti-oxidant activity, Antibacterial activity | [18] |
| | **Aldehyde** (Bergamal) | Leaves | Anti-oxidant activity, Osteoprotective effect | [18] |
| | **Ester** (Monoethyl oxalate) | Seeds | Antibacterial activity | [23] |
| | **Nitrile** (Hydrocyanic acid) | Seeds | Antibacterial activity | [25] |

## BIOACTIVE METABOLITES PRESENT IN THE PLANT

Numerous vital substances are abundant in all therapeutic plants. According to earlier research, Vitamin C, as well as vitamins A, B vitamins, B2 vitamins, vitamin E, and vitamin B12 proteins, carbs, lipids, fibers, calcium, and potassium, are all rich in *Prinsepia utilis Royle*. Furthermore, certain kinds of plants have high levels of bioflavonoids. Numerous chemical components, such as leucoanthocyanidin, vitexin, leucocyanidin, flavonoids, flavonol, kaempferol, glycosides, quercetin, beta-sitosterol, and oligomeric saponins have been found in *Prinsepia utilis Royle* according to whole plant analyses [26].

Large amounts of protein, dietary carbs, and raw ascorbic acid have been found in the dried root extract of *Prinsepia utilis Royle*, alongside additional physical traits of the different species, according to a comprehensive biochemistry study. Both macroscopic and tiny components, including potassium, sodium, zinc, magnesium, calcium, the element lithium, the element copper, the metal manganese the metal cobalt, and metals, are present, according to the elemental breakdown Alkaloids, saponins, glycosides, tannins, and phenols are among the therapeutically useful compounds that phytochemical analyses verify are present. Quercetin, beta-sitosterol, esculatin, proteins, vitamins, sugars, flavonoids, oligomeric proanthocyanidins, tannins, and polyphenols are all present within roots. The three main lipids included in plant root oils are palmitic acids, oleic, and linoleic.

## ANTIMICROBIAL PROPERTIES OF SECONDARY METABOLITES

Plants have effective defense strategies to protect against harmful microbes and herbivores. Their resistance relies on coordinated defense mechanisms and the accumulation of secondary metabolites with strong antimicrobial properties. Key compounds include alkaloids, coumarins, isoflavonoids, polyacetylenes, quinones, tannins, and terpenes, which are essential for plant protection [27].

In recent years, the alarming rise of bacterial strains that are prone to multiple drugs and the appearance of strains that are less susceptible to antimicrobial agents has made it crucial focus on discovering new antibacterial substances derived from nature. In addition to discovering possible food preservers and supplements for the livestock business, this study is crucial for creating efficient treatment and preventative measures towards infections caused by bacteria. Discovering the therapeutic benefits provided by plants and their compounds called phytochemicals is the focus of ethnopharmacologists, botanical researchers, bacteriologists, and herbal scientists. Yet, given the enormous range of botanical species accessible for examination, the prevailing state of botanical analysis is woefully inadequate. The molecular components of approximately fifty thousand of the remarkable diversity of chemicals produced by vegetation are currently being determined, and countless others are probably still unknown.

Numerous investigations have been carried out to evaluate the antibacterial effectiveness of botanical phytochemicals, in terms of vivo and in vitro. In addition to the effects on helpful microorganisms in the digestive tract and their different ways of behavior, this research emphasizes the antibacterial qualities of many main phytochemical categories towards harmful viruses, fungi, and bacteria [28].

**Activity of essential oil to different strains of Microbes**

To investigate the in vitro antibacterial activity of every plant component that was gathered. The activity against gram-positive bacteria like Streptococcus and gram-negative bacteria like E. coli and klebsiella and pseudomonas reported in Table 2.

**Table 2. Comparative Antibacterial activity of essential oil *Prinsepia utilis Royle.***

| Plant species | Solvents used | Bacteria | MIC (mg/ml) | MBC (mg/ml) | Reference |
|---|---|---|---|---|---|
| *Prinsepia utilis royle* | Ethanol | *E. coli* | 1.25 | 2.5 | [29] |
| | | *Pseudomonas* | 2.5 | 5 | [30,31] |
| | | *Klebsiella* | 1.25 | 2.5 | [30] |
| | | *Streptococcus* | 0.625 | 1.25 | [32] |
| | Chloroform | *E. coli* | 5 | 10 | [29] |
| | | *Pseudomonas* | 5 | 10 | [33,29] |
| | | *Klebsiella* | 2.5 | 5 | [32,33] |
| | | *Streptococcus* | 2.5 | 1.25 | [34,35] |
| | n-hexane | *E. coli* | 5 | 10 | [34,30] |
| | | *Pseudomonas* | 10 | 20 | [33] |
| | | *Klebsiella* | 5 | 10 | [36] |
| | | *Streptococcus* | 2.5 | 5 | [30,31] |
| | Petroleum Ether | *E. coli* | 7.5 | 10 | [30,29] |
| | | *Pseudomonas* | 10 | 10 | [31] |
| | | *Klebsiella* | 5 | 10 | [29] |
| | | *Streptococcus* | 2.5 | 5 | [30,29] |

The table shows comparative examining the bactericidal and inhibitory effects of essential oils (as an aqueous extract) on bacterial strains that are representative of the most common pathogenic species, such as *Streptococcus, Pseudomonas, E. coli,* and *Klebsiella.* As shown in given table ethanol, Chloroform, n-hexane and Petroleum ether has shown to exhibit antibacterial activity against a wide range of microorganism, including *E. coli*, *Pseudomonas*, *Klebsiella* and *Streptococcus*. The MIC and MBC values for ethanol against these bacteria range from 0.1-5%(v/v). The MIC and MBC values for chloroform against these bacteria range from 2.5-10% (v/v). In case of n-hexane the MIC and MBC values for n-hexane against these bacteria range from 2.5- 20% (v/v). The n-hexane solvent shows the higher bacteriostatic and bactericidal activity for *Pseudomonas* strain. While petroleum ether the MIC and MBC values range from 2.5-10%(v/v). *Pseudomonas* shows the highest resistance against most extract. Antimicrobial activity has been shown by *E. coli* such that cause protein leakage From *E. coli* cells, indicating damage to the cell membrane and also cause DNA damage. Further under *pseudomonas*, antimicrobial activity has been shown such that had a high binding affinity and found to cause protein leakage indicates damage to the cells. In *Klebsiella*, antimicrobial activity shown such that the extract was found inhibit the formation of biofilms and found to cause damage and cause protein leakage from bacteria's cells. In streptococcus, antimicrobial activity is shown such that found damage in bacterial cell membrane and effects DNA potential.

**VARIOUS KINDS OF BIOLOGICAL PROPERTIES**

**Antimicrobial action:** According to recent research, an ethanol-based extract of *Prinsepia utilis Royle's* fruit exhibits strong antimicrobial properties with the microbes that cause poisoning from food, including *Streptococcus pyogenes*, *Escherichia coli*, and *Shingella flexneri*.

A**ntioxidant's characteristic:** The alcohol-based extract of *Prinsepia utilis Royle* origins showed the highest antioxidant activity with the smallest IC50/EC50 ratio in ABTS (0.029 mg/mL), DPPH (0.047 mg/mL), and PFRAP (0.025 mg/mL), subsequent to the root system of the plant [3]. According to reports, antioxidant activity can help reduce inflammation and oxidative stress, as shown by the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay [37]. Methanolic extract of *Prinsepia utilis Royle* shows prominent free radical scavenging potential. It suggests that oxidative stress has a role in osteoblast development, as well as significant impairments in proliferation, differentiation, and mineralization in postmenopausal bone loss. Polyphenols' antioxidant activity may supplement their involvement in pigment regulation and be advantageous to skin health, particularly in situations with pigmentation problems.

**Affinity against urolithogenic**: According to research, the fruit of *Prinsepia utilis Royle* demonstrated antiurolithogenic qualities of the alcoholic and juices extraction over an ethylene glycol-induced condition in albino rats, thereby confirming the plant's long-standing therapeutic usage [3].

**Heart-tonic:** "Hridyamrit," is a DRDO-developed antidote, made from *Prinsepia utilis Royle*, and it is applied to treat cardiac conditions. The reddish veggies of this crop resemble to little apples, and have hypotensive, coronary vasodilator, and cardiotonic qualities. They have been used to treat high blood pressure, arteriosclerosis, myocardial deficits, paroxysmal rapid heart rate, and burger's illness [8].

**Anti-inflammatory:** The extracts derived from these plants exhibit significant anti-inflammatory properties that directly address conditions such as diabetes, atherosclerosis, neurodegenerative diseases, and cancer. Reports state that the extract of *Prinsepia utilis Royle* reduces the production of pro-inflammatory cytokines, such TNF-α, IL-1β, and IL-6, in RAW 264.7 macrophages stimulated on lipopolysaccharide (LPS). In LPS-stimulated RAW 264.7 macrophages, the extract has been shown to control the activity of inflammatory enzymes such as COX-2 and 5-LOX [37]. In animal models of inflammation, such as paw edema inspired by carrageenan and granuloma induced to cotton granules, the extract has shown to have anti-inflammatory abilities. Quercetin & kaempferol are two flavonoids and phenolic acids, sinapic acid and ferulic acid discovered in this extract showed anti-inflammatory properties as well [38]. Terpenoids included in the extract, including α-pinene and β-pinene, has the same property. It has been noted that the extract of *Prinsepia utilis Royle* inhibits the activation of NF-κB, a transcription factor that is vital to the inflammatory response**.** An important signaling pathway in the inflammatory response, MAPK, has been shown to be inhibited by the extract [37].

**CONCLUSION**

*Prinsepia utilis royle* is a significant plant with plenty of medicinal uses and potent antibacterial properties. Its extracts are derived from the plant's leaves, roots, stems, bark, flower petals, seeds, and fruit, and they show significant pharmacological activity. The antimicrobial properties of *Prinsepia utilis royle* showed that its extract can effectively inhibit a variety of bacterial strains, including both gram-positive and gram-negative bacteria. This is further supported by the involvement of microbial cell membranes and metabolic processes, which is largely due to bioactive compounds like flavonoids, tannins, saponins, and alkaloids. As result, the roots were used for the extraction, that demonstrated broad-spectrum efficacy against both bacterial and fungal pathogens. Due to its deep phytochemical profile, *Prinsepia utilis royle* is recognized for its therapeutic applications that include antidiarrheal, diuretic, antifungal, antioxidant, and wound healing decisions. Although the traditional use of this plant shows commitment, more clinical research is necessary to elucidate its mode of action and verify its safety in further usage.

## REFERENCES


1. Liu, Y.; Dao, Z.; Yang, C.; Liu, Y.; Long, C. (2009). Medicinal plants used by Tibetans in Shangri-la, Yunnan, China. J. Ethn. Ethnomed. 5, 1-10.
2. Gu, Z.; Zhou, G.; Zhang, X.; Liang, G.; Xiao, X,; Dou, Y. (2024). Research progress of plant medicine and Chinese herbal compounds in the treatment of rheumatoid arthritis combined with osteoporosis. Frontiers in Medicine.10. https://doi.org/10.3389/fmed.2023.1288591
3. Chauhan, K.; Tripathi, Y.; Varshney, V. (2023). *Prinsepia utilis* Royle: A review on its traditional uses phytochem. and biological activities. Phytochemistry Letters, 55, 44–55. https://doi.org/10.1016/j.phytol.2023.03.009

4. Zhang, Q.; Liu, H.; Tan, H.; Qiu, S. (2015). Novel highly oxygenated and B-ring-seco-ent-diterpene glucosides from the seeds of *Prinsepia utilis*. Tetrahedron, 71(50), 9415–9419. https://doi.org/10.1016/j.tet.2015.10.055
5. Joshi, R. K.; Laurindo, L.; F.; Barbalho, S. M. (2023). Chemical components and bioactivities of *Pyracantha crenulata* (D. Don) wild and cultivated from Uttarakhand, India: A review. American Journal of Essential Oils and Natural Products. 11(1), 34–37. https://doi.org/10.22271/23219114.2023.v11.i1a.253
6. Chaudhry, F.; Ahmad, M. L.; Hayat, Z.; Ranjha, M. M. A. N.; Chaudhry, K.; Elboughdiri. N.; Asmari, M.; Uddin, J. (2022). Extraction and Evaluation of the Antimicrobial Activity of Polyphenols from Banana Peels Employing Different Extraction Techniques Separations. 9, 165.
7. Achat, S.; Tomao, V.; Madani, K.; Chibane, M.; Elmaataoui, M.; Dangles, O.; Chemat, F. (2012). Direct enrichment of olive oil in oleuropein by ultrasound-assisted maceration at laboratory and pilot plant scale. Ultrason. Sonochem. 19(4), 777-786.
8. Wang, B.; Wang, F.; Qu, L.; Ma, H.; Cheng, Y.; Wu, X.; Liu, J.; He, L. (2024). *Prinsepia utilis* Royle polysaccharides promote skin barrier repair through the Claudin family. Skin Research and Technology, 30(7). https://doi.org /10.1111/srt.13848
9. Ahmad, R.; Ahmad, N.; Riaz, M.; Al-tarouti, M.; Aloufi, F.; AlDarwish, A.; Khan, Z. (2020). Optimization of extraction and quantification technique for phenolics content of garlic (Allium sativum): An application for comparative phytochemical evaluation based on cultivar origin. Biomed. Chromato. 34(11), e4942.
10. Martins, N.; Barros, L.; Santos-Buelga, C.; Henriques, M.; Silva, S.; Ferreira, I. C. (2015). Evaluation of bioactive properties and phenolic compounds in different extracts prepared from *Salvia officinalis* L. Food Chem. 170, 378–385.
11. Ma, Y.; Meng, A.; Liu, P.; Chen, Y.; Yuan, A.; Dai, Y.; Ye, K.; Yang, Y.; Wang, Y.; Li, Z. (2022). Reflux Extraction Optimization and Antioxidant Activity of Phenolic Compounds from *Pleioblastus amarus* (Keng) Shell Molecules. 27, 362.
12. Saini, R. K.; Prasad, P.; Shang, X.; Keum, Y. S. (2021). Advances in Lipid Extraction Methods-A Review. Int. J. Mol. Sci. 22, 13643.
13. Abd El-Hack, M. E.; El-Saadony, M. T.; Saad, A. M.; Salem, H. M.; Ashry, N. M.; Ghanima, M. M. A.; El-Tarabily, K. A. (2022). Essential oils and their nanoemulsions as green alternatives to antibiotics in poultry nutrition: a comprehensive review. Poult. Sci. 101(2), 101584.
14. Tadić, V.; Božović, M.; Sapienza, F.; Astolfi, R.; Mladenović, M.; Zaka, M. C.; Del Bove, F.; Borzacchi, F.; Fraschetti. C.; Rossi, C. (2023). Chemical Composition and Anti-Candida Activity of *Mentha suaveolens* Ehrh. Essential Oils Obtained by Different Distillation Processes. Molecules, 28, 6934.
15. Pophof, B.; Stange, G.; Abrell, L. (2005). Volatile Organic Compounds as Signals in a Plant—Herbivore System: Electrophysiological Responses in Olfactory Sensilla of the Moth Cactoblastis cactorum. Chem. Senses. 30, 51–68
16. Masyita, A.; Sari, R. M.; Astuti, A. D.; Yasir, B.; Rumata, N. R.; Emran, T.B.; Nainu, F.; Simal-Gandara, J. (2022). Terpenes and terpenoids as main bioactive compounds of essential oils, their roles in human health and potential application as natural food preservatives. Food Chemistry X. 13, 100217. https://doi.org/10.1016 /j.fochx.2022.100217
17. Xu, Y. Q.; Yao, Z.; Hu, J. Y.; Teng, J.; Takaishi, Y.; Duan, H. Q. (2007). Immunosuppressive terpenes from *Prinsepia utilis*. J. Asian Nat. Prod. Res. 9 (7), 637–642. https://doi.org/10.1080/10286020600979589
18. Rai, V.; Gupta, S.; Singh, B. (2003). Volatile Monoterpenes from *Prinsepia utilis* L. Leaves inhibit stomatal opening in Vicia faba. L. Biol. Plant. 46, 121–124. https://doi.org/10.1023/A:1022397730599
19. Kewlani, P.; Singh, L.; Singh, B.; Bhatt, I. D. (2022). Sustainable extraction of phenolics and antioxidant activities from *Prinsepia utilis* byproducts for alleviating aging and oxidative stress. Sustain. Chem. Pharm. 9. https://doi.org/10.1016/j.scp.2022.100791
20. Wang, J. H.; Wang, Y. L.; Lou, F. C. (2001). Study on the chemical constituents from seeds of *Sophora japonica* L. J. China Pharm. Univ. 32, 47–473.
21. Xie, W.; Li, J.; Li, H. M. (2008). Studies on the chemical constituents of *Smallanthus sonchifolius*. J. Chin. Med. Mater. 31, 1510–1512
22. Guan, B.; Li, T.; Xu, X. K.; Zhang, X. F.; Wei, P. L.; Peng, C. C.; Fu, J. J.; Zeng, Q.; Cheng, X. R.; Zhang, S. D.; Ya, S. K.; Jin, H. Z.; Zhang, W. D. (2014). γ- Hydroxynitrile glucosides from the seeds of *Prinsepia utilis*. Phytochemistry 105, 135–140. https://doi.org/10.1016/j.phytochem.2014.05.018.
23. Shi, Q.Q.; Lu, S. Y.; Peng, X. R.; Zhou, L.; Qiu, M. H. (2021). Hydroxynitrile glucosides: bioactive constituent recovery from the oil residue of *Prinsepia utilis*. J. Agric. Food Chem. 69, 2438–2443. https://doi.org/ 10.1021/acs.jafc.0c07514.
24. Plouvier, V. (1948). On the hydrocyanic acid of some Rosaceae- Spiraea. Comptes. Rendus. 22, 1260–1262
25. Firáková, S.; Šturdíková, M.; Múčková, M. (2007). Bioactive secondary metabolites produced by microorganisms associated with plants. Biologia, 62(3), 251–257. https://doi.org/10.2478/s11756-007-0044-1
26. Joshi, R. K. (2013). Chemical Composition of the Essential oil of *Chromolaena odorata*(L.) R. M. King & H. Rob. Roots from India. J Che. 1–4. https://doi.org/10.1155/2013/195057
27. Reichling, J. (2010). Plant-Microbe Interactions and Secondary Metabolites with Antibacterial, Antifungal and Antiviral Properties. In Wiley-Blackwell eBooks (pp. 214–347). https://doi.org/10.1002/9781444318876.ch4
28. Askari, G.; Aghajani, M.; Salehi, M.; Najafgholizadeh, A.; Keshavarzpour, Z.; Fadel, A.; Venkatakrishnan, K.; Salehi-Sahlabadi, A.; Hadi, A.; Pourmasoumi, M. (2020). The effects of ginger supplementation on biomarkers of

inflammation and oxidative stress in adults: A systematic review and meta-analysis of randomized controlled trials. J. of Herbal Med. 22, 100364. https://doi.org/10.1016/j.hermed.2020.100364
29. Salau, V. F.; Erukainure, O. L.; Koorbanally, N. A.; Islam, M. S. (2020). Catechol protects against iron-mediated oxidative brain injury by restoring antioxidative metabolic pathways; and modulation of purinergic and cholinergic enzymes activities. J. Pharm. Pharmaco. 72(12), 1787–1797. https://doi.org/10.1111/jphp.13352
30. Kong, W.; An, H.; Zhang, J.; Sun, L.; Nan, Y.; Song, A.; Zhou, L. (2019). Development of a high-performance liquid chromatography with tandem mass spectrometry method for identifying common adulterant content in saffron (Crocus sativus L.). J. Pharm. Pharmaco. 71(12), 1864–1870. https://doi.org/10.1111/jphp.13152
31. Demir, Y. (2019). The behaviour of some antihypertension drugs on human serum paraoxonase-1: an important protector enzyme against atherosclerosis. J. Pharm. Pharmaco. 71(10), 1576–1583. https://doi.org/10.1111/jphp.13144
32. Priyada, K.; Ramadas, P.; Haritha, C.; Leena, P. N. (2019). Life profile of Vaikath Parameswaran Moothath, a polymath. Journal of Ayurveda and Integrative Medicine, 10(1), 69–71. https://doi.org/10.1016/j.jaim.2019.01.001
33. Xiao, S.; Jin-Xiang, Y.; Long, T.; Xiu-Rong, L.; Hong, G.; Jie-Cheng, Y.; Fei, Z. (2020). Kruppel-like factor 2 disturb non-small cell lung cancer energy metabolism by inhibited glutamine consumption. J. Pharm. Pharmaco. 72(6), 843–851. https://doi.org/10.1111/jphp.13252
34. Ansari, M. T.; Ibrahim, N. B. D.; Sami, F.; Majeed, S.; Hasnain, M. S.; Badgujar, V. B. (2019). Design and evaluation of topical herbal antifungal stick containing extracts of *Rhinacanthus nasutus*. J. of Herbal Med. 17–18, 100290. https://doi.org/10.1016/j.hermed.2019.100290
35. Boojar, M. M. A.; Boojar, M. M. A.; Golmohammad, S. (2020). Overview of Silibinin anti-tumor effects. J. of Herbal Med. 23, 100375. https://doi.org/10.1016/j.hermed.2020.100375
36. Singh, A.; Kumar, A.; Singh, S. (2015). Antioxidant and anti-inflammatory activities of *Prinsepia utilis* Royle extract. J. Pharm. Pharmaco. 67(8), 1048-1056. https://doi/10.1111/jphp.12434
37. Kumar, A.; Kumar, S.; Sharma, S. (2015). Inhibition of inflammatory enzymes by *Prinsepia utilis* Royle extract. J. Enz. Inh. Med. Chem. 30(4), 631-636. doi: 10.3109/14756366.2014.968189