Nepal J Biotechnol. 2024 Dec; 12 (2): 101-108 Research Article DOI: https://doi.org/10.54796/njb.v12i2.339

Nepal Journal of Biotechnology
Publisher: Biotechnology Society of Nepal ISSN (Online): 2467-9313
Journal Homepage: https://nepjb.com/index.php/NJB ISSN (Print): 2091-1130

A Comparative Study on the Phytochemical Profile, Antimicrobial Activity and Antioxidant Capacity of Flowers and Leaves from Selected Medicinal Plants

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Received: 12 Sep 2024; Revised: 09 Dec 2024; Accepted: 23 Dec 2024; Published online: 31 Dec 2024

Abstract

Recently, there has been an increase in global acclaim for historically utilized medicinal plants. This study aimed to prepare 70% ethanolic extracts from various medicinal plants and evaluate their phytochemical profiles, antimicrobial properties, and antioxidant activities. Twelve medicinal plant samples (six flowers and six leaves of same medicinal plant) (*Rhododendron arboreum, Hibiscus rosa sinensis, Rosa damascena, Tagetes erecta, Bougainvillea glabra* and *Chrysanthemum grandiflorum)* were collected and processed. Standard procedures were employed to assess the phytochemical composition of these extracts. Antimicrobial activity was evaluated using the agar well diffusion method, while antioxidant capacity was determined using the DPPH (1,1-diphenyl-2-picrylhyrazyl) assay. Phytochemical screening revealed the presence of alkaloids, coumarin, glycosides, flavonoids, tannins, quinones, reducing sugars, and saponins in most of the extracts. Notably, *R. damascena*, *T. erecta*, and *R. arboreum* demonstrated antimicrobial activity against *Staphylococcus aureus* (ATCC 6538P), with *R. damascena* showing the strongest inhibition across all concentrations (100, 200, 300, and 400 mg/mL), with the highest inhibition zone of 20 mm at 400 mg/mL. However, no extracts displayed antibacterial activity against *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, or *Escherichia coli*. Regarding antioxidant activity, ascorbic acid had an IC_{50} value of 7.928 µg/mL, while the plant extracts showed varying levels of antioxidant potential, with *R. damascena* leaf extract having the lowest IC_{50} value of 21.10 µg/mL and *C. grandiflorum* leaf extract showing the highest IC_{50} value of 241.21 µg/mL. These findings indicate that the selected plants possess antimicrobial and antioxidant properties, and their phytochemical content may contribute to their therapeutic potential.

Keywords: Phytochemical, antimicrobial activity, antioxidant, medicinal plants, DPPH assay, IC_{50} value

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Introduction

Plants have served as a vital source of medicinal compounds for centuries, with around 75-80% of the population in developing nations depending on herbal treatments for primary healthcare. This reliance is largely due to the cultural acceptance and low occurrence of side effects associated with plant-based remedies [1]. In Nepal, traditional medical practices such as Traditional Chinese Medicine (TCM) and Tibetan Amchi Medicine (TAC) have been utilized for centuries, with knowledge of these systems being passed down through generations [2].

Nepal's diverse biodiversity, with over 7000 medicinal plant species, is attributed to its varied topography, climate, and soil conditions [3]. These plants produce an array of secondary metabolites like glycosides, phenolics, alkaloids, and terpenoids that contribute to their pharmacological activities [4]. Natural antimicrobials from plants offer promising alternatives to reduce antibiotic dependence, combat pathogenic resistance, prevent food contamination, and enhance human immunity.

Flowers, as natural creations, are appreciated not only for their aesthetic appeal but also for their nutritional benefits and potential therapeutic properties. Growing interest in edible flowers is being driven by their nutritional value. Previous scientific research has indicated that floral tissues are a significant source of natural antioxidants [5].

Additionally, it is asserted that many floral beverages have anti-carcinogenic properties, which are most likely linked to their capacity to scavenge free radicals [6]. According to Suksathan et al (2021), [7] phenolics and flavonoids in herbal tea infusions have anti-glycation activity that contributed to difficulties with aging and diabetes.

Oxidative stress, resulting from an imbalance of free radicals, is a contributing factor to several chronic conditions, including cancer, diabetes, cardiovascular diseases, and neurodegenerative disorders. Natural antioxidants derived from plants have the ability to

Table 1. List of Medicinal Plants used

Name of Plants	Local Name	Family	Part used	Month of collection	Location/District
Rhododendron arboreum	Lali gurans	Ericaceae	Flower and Leaf	January/ February	Kathmandu
Hibiscus rosa sinensis	Ghantiful	Malvaceae	Flower and Leaf	January	Chitwan
Rosa damascena	Gulab	Rosaceae	Flower and Leaf	January/ February	Chitwan
Tagetes erecta	Sayapatri	Asteraceae	Flower and Leaf	January/ February	Chitwan
Bougainvillea glabra	Kagazi ful	Nyctaginaceae	Flower and Leaf	January	Chitwan
Chrysanthemum grandiflorum	Godawari	Asteraceae	Flower and Leaf	January/ February	Kathmandu

counteract this oxidative damage by scavenging reactive oxygen species (ROS) through the process of radical chain reactions [8].

Because drug safety is still a major concern on a global scale, the current medications used to treat infectious diseases are of concern. The majority of synthetic medications have adverse effects, and the majority of bacteria have acquired resistance to them [9]. Antimicrobial elements from promising plants should be researched to solve this issue. These plant-based medications are less toxic, have few adverse effects, and are also reasonably priced. They are effective in treating infections while also reducing many of the side effects commonly associated with synthetic antimicrobials [10].

Despite growing interest in scientific validation of traditional medicinal plants in Nepal, many remain unexplored for their therapeutic potential. Plant bioactivities are influenced by genetic, geographic, climatic, soil, seasonal, and developmental factors, necessitating comprehensive investigations [11].

Medicinal plants offer a culturally acceptable and cost-effective means of primary healthcare, with minimal adverse effects. However, the global challenge of antibiotic resistance demands alternative approaches, and phytochemicals present a promising solution as potential therapeutic agents, nutraceuticals, food additives, and preservatives [12].

The objective of this study is to evaluate the phytochemical components, antimicrobial properties, and antioxidant potential of both flower and leaf extracts from six medicinal plants (*R. arboreum, H. rosa sinensis, R. damascena, T. erecta, B. glabra, and C. grandiflorum*) traditionally used in Nepal. The findings will contribute to a better understanding of their properties, safety, and efficacy, paving the way for future development of novel drugs, supplements, and preservatives.

Material and methods

Sample collection

The plant samples (flower and leaves) used in the study were collected from Chitwan and Kathmandu districts of Nepal. The medicinal plants used in this study, along with the specific plant parts, collection months, and sample locations, are outlined in **Table 1**.

Preparation of sample extract

The extract was prepared using the cold percolation method. Initially, the samples were air-dried at room temperature for 15-20 days. Then, 20 grams of the ground sample were placed in a conical flask, and 70% ethanol was added in a 1:5 (gm:mL) ratio. The mixture was left to stand at room temperature for four days. Afterward, the solution was filtered through Whatmann No. 1 filter paper. The filtrate was then concentrated using a rotary evaporator to remove the solvent. Finally, the extract was collected and stored in a glass vial at 4°C for further use.

Preparation of plant extract solution for phytochemical analysis

To prepare the stock solution for phytochemical screening, 1 gram of the plant extract was dissolved in 10 mL of distilled water.

Phytochemical analysis

Phytochemical analysis was performed to identify bioactive compounds, including alkaloid, anthraquinone, coumarin, glycoside, flavonoids, tannin, quinine, reducing sugar, saponin and steroid by following procedures described below.

I. Test for Alkaloid (Mayer's test)

To test for alkaloids, 0.5 mL of the stock solution was mixed with 0.5 mL of distilled water, followed by the addition of 1.5 mL of 2% hydrochloric acid. The mixture was then treated with 0.5 mL of Mayer's reagent. The presence of alkaloids was confirmed by the formation of turbidity or a yellow precipitate [14].

II. Test for Coumarin

0 A 0.5 mL aliquot of the stock solution was mixed with 0.5 mL of distilled water, and then four drops of 1% sodium hydroxide were added. The formation of a yellow color confirmed the presence of coumarin [15].

III. Test for Anthraquinone

0.5 mL of the stock solution was mixed with 0.5 mL of ammonia solution and shaken thoroughly. The development of a reddish color indicated the presence of anthraquinone [16].

IV. Test for Flavonoid

One mL of the extract was treated with a few drops of 1% NaOH solution until a yellow color developed. Then, 5-6 drops of dilute HCl were added. The disappearance of the yellow color, if present, indicated the presence of flavonoid [17].

V. Test for Tannin

0.5 mL of the stock solution was mixed with 1 mL of distilled water, followed by the addition of 3-4 drops of 5% ferric chloride. The solution was observed for the development of a deep blue or blackish color [14].

VI. Test for Glycoside

About 0.5 mL of the stock solution was dissolved in 1 mL of glacial acetic acid, followed by the addition of 2-3 drops of 5% ferric chloride and 0.5 mL of concentrated sulfuric acid. The presence of glycosides was confirmed by the appearance of a reddish-brown color at the interface of the two layers and a bluish-green color in the upper layer [18].

VII. Test for Quinine

0.5 mL of the stock solution was mixed with 0.5 mL of distilled water, followed by the addition of 4-5 drops of 1N sodium hydroxide. The formation of a red, blue, or green color indicated the presence of quinine [19].

VIII. Test for Saponin (Foam test)

1 mL of the stock solution was diluted with 3 mL of distilled water and the mixture was shaken vigorously. The formation of a stable foam layer that lasted for 10 minutes or longer indicated the presence of saponin [14].

IX. Test for Reducing sugar (Fehling's test)

0.5 mL of the stock solution was mixed with 0.5 mL of water, followed by the addition of 5-8 drops of Fehling's solutions A and B. The mixture was then heated in a water bath. The appearance of a brick-red precipitate confirmed the presence of reducing sugars [14].

X. Test for Steroid

0.5 mL of the stock solution was dissolved in 1 mL of chloroform, followed by the addition of 1 mL of concentrated sulfuric acid. Upper layer was observed for red colour and sulfuric layer was observed for yellow coloration with green fluorescence [15].

Test organisms

Standard ATCC culture of *Klebsiella pneumoniae* (ATCC 700603) and *Pseudomonas aeruginosa* (ATCC 9027) from the Natural Products Research Laboratory in Thapathali, Kathmandu, as well as *Staphylococcus aureus* (ATCC 6538) and *Escherichia coli* (ATCC 25922) were obtained from Sukraraj Tropical and Infectious Diseases Hospital, Teku, Kathmandu. The ATTC culture were taken and sub-cultured on Nutrient broth (NB) and later cultured on petri-plates having Nutrient Agar (NA).

Standardization of inoculum

The test organisms were subcultured onto fresh Nutrient Agar plates and incubated at 37°C for 24 hours. For each bacterial strain, 3-4 isolated colonies were suspended in 5 mL of Nutrient Broth and incubated for 4 hours. The turbidity of the resulting culture was then adjusted to match the 0.5 McFarland standard (equivalent to 1.5×10^8 CFU/mL) before use [20].

Preparation of plant extract concentration for antimicrobial test

A stock solution of 1 gram of plant extract was prepared by dissolving it in 1 mL of DMSO, resulting in a concentration of 1000 mg/mL. These stock solutions were further diluted to obtain final concentrations of 400 mg/mL, 300 mg/mL, 200 mg/mL, and 100 mg/mL.

Antibacterial activity

The antibacterial activity of the extracts was evaluated using the agar well diffusion method as outlined by Bauer et al. (1996) [21]. The bacterial culture was prepared and adjusted to match the 0.5 McFarland standard. A sterile cotton swab was used to evenly spread the culture on a Mueller-Hinton agar plate. Using a sterile 6 mm diameter well borer, wells were made in the agar plate containing the inoculum. Then, 100 µl of each extract was added to the wells. The plate was left at room temperature to allow the extracts to diffuse into the agar. Afterward, the plates were incubated at 37°C for 24 hours. Antibacterial activity was assessed by measuring the zone of inhibition around each well. A 10% concentration of dimethyl sulfoxide was used as a negative control. The antibacterial activity of the extracts was tested at concentrations ranging from 100 to 400 µg/mL.

Estimation of total antioxidant activity

The antioxidant activity was assessed using the DPPH (1,1-diphenyl-2-picrylhydrazyl) radical scavenging assay, as described by Khan et al. [22]. Different concentrations of the extract were prepared in Eppendorf tubes, to which a 0.4% ethanolic solution of DPPH was added. The mixtures were then incubated at room temperature for one hour. After incubation, the solution was transferred to a 96-well microtiter plate, and absorbance was measured at 517 nm using a blank for reference in an ELISA plate reader. The results were expressed in micrograms per mL of the test solution. The

Table 2. Percentage yield of samples in 70% ethanol per 100 grams

SN	Plants		Weight of sample in grams	Weight of extract in grams	Percentage yield (%)
1	*Rhododendron arboreum*	flower	20	4.63	23.2
		leaf	20	1.82	9.1
2	*Hibiscus rosa sinensis*	flower	20	3.28	16.4
		leaf	20	1.79	8.95
3	*Rosa damascena*	flower	20	2.83	14.2
		leaf	20	1.68	8.4
4	*Tagetes erecta*	flower	20	2.2	11
		leaf	20	1.6	8
5	*Bougainvillea glabra*	flower	20	2.5	12.5
		leaf	20	1.91	9.55
6	*Chrysanthemum grandiflorum*	flower	20	3.66	18.3
		leaf	20	2.5	12.5

Table 3. Phytochemical screening in plant extract

SN	Test	Plants											
		RHF	RHL	HIF	HIL	ROF	ROL	TAF	TAL	BOF	BOL	CHF	CHL
1	Alkoloid	−	+	−	−	−	−	+	−	−	−	+	+
2	Anthraquinone	−	+	−	−	−	−	+	−	−	−	−	−
3	Coumarin	−	+	−	−	−	+	+	+	+	−	+	+
4	Glycoside	−	−	+	−	+	+	+	+	+	+	+	+
5	Flavonoids	+	+	−	+	−	+	+	+	+	+	+	+
6	Tannin	+	+	+	+	+	+	+	+	+	+	+	+
7	Quinine	+	−	+	−	+	−	−	−	−	−	−	−
8	Reducing sugar	+	+	+	−	+	+	+	−	−	−	−	+
9	Saponin	−	+	−	+	−	+	+	+	+	+	+	+
10	Steroid	+	−	−	−	−	−	−	−	+	−	−	−

The plants are denoted as RHF= *Rhododendron arboreum* flower, RHL= *Rhododendron arboreum* leaf, HIF= *Hibiscus rosa sinensis* flower, HIL= *Hibiscus rosa sinensis* leaf ,ROF= *Rosa damascena* flower ,ROL= *Rosa damascena* leaf, TAF=Tagetes erecta flower, TAL=*Tagetes erecta* leaf, BOF= *Bougainvillea glabra* flower, BOL= Bougainvillea glabra leaf, CHF=Chrysanthemum *grandiflorum* flower, *CHL=Chrysanthemum grandiflorum* leaf

antioxidant activity was calculated using the following equation:

Percentage Radical Scavenging Activity (RSA):

%RSA= [(Absorbance of control-Absorbance of sample)/Absorbance of control] × 100.....(1)

Calculation of IC_{50} value

The IC_{50} value denotes the concentration of the sample needed to scavenge 50% of the DPPH free radical.

IC_{50} value was calculated from % inhibition. Absorbance at 517nm is determined after 30 minutes using spectrophotometer and IC_{50} is determined [23].

Increased free radical scavenging activity is demonstrated by a reaction mixture showing reduced absorbance.

IC_{50} was calculated from regression equation of line obtained by plotting a graph of concentration versus scavenging percentage.

IC_{50} Value $= \frac{Y-B}{m}$ .....(2)

Where, Y is 50% inhibition concentration,

B is Y intercept of the standard curve

m is slope of the standard curve

Results

Percentage yield

Out of twelve samples from six medicinal plants (flower and leaves) tested, the maximum yield percentage was shown by *R. arboreum* flower that was 23.2 % followed by *C. grandiflorum* flower with 18.3% yield. Similarly, the least extract yield was found in *T. erecta* leaf that was 8% followed by *R. damascena* leaf with 8.4% yield (**Table 2**).

Phytochemical screening in plant extracts

Most of the flower and leaf extracts gave positive result for presence of tannin, saponin and glycoside. Maximum number of phytochemicals (8 types) were found in *T. erecta* as shown in (**Table 3**).

Antimicrobial activity of plant extracts against test organisms

Only four flower and leaf extracts demonstrated effectiveness against *S. aureus*. The flower extract of *R. damascena* exhibited the maximum zone of inhibition of 20 mm, at a concentration of 400 mg/ml (**Figure 1** and **Figure 2**). Rest of the samples didn't show any antimicrobial activity at the given concentrations. No samples exhibited antibacterial property against *K. pneumoniae, P. aeruginosa* and *E. coli* (**Table 4**).

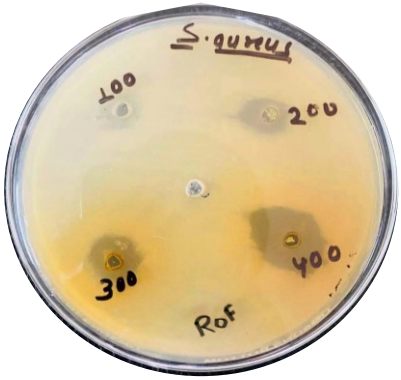

Figure 1. Antimicrobial activity exhibited by flower extract of *R. damascena* against *S. aureus* (at 400mg/mL; 300mg/mL; 200mg/mL; 100mg/mL)

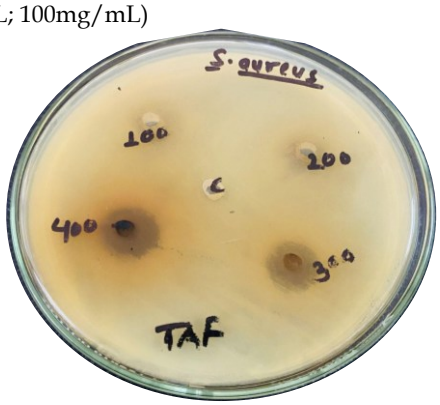

Figure 2. Antimicrobial activity exhibited by flower extract of *T. erecta* against *S. aureus* (at 400mg/mL; 300mg/mL; 200mg/mL; 100mg/ml)

Table 4. Antimicrobial activity of plant extract against *Staphylococcus aureus*.

Sample	Concentration used(mg/ml)	ZOI (mm) against test organisms	
		Flower	Leaf
R. arboreum	300	0	6
	400	0	10
R.damascena	100	8	7
	200	10	8
	300	15	13
	400	20	15
T.erecta	100	6	0
	200	9	0
	300	12	0
	400	15	0

Antioxidant activity

The antioxidant activity of flower and leaf extract were determined by the DPPH method where the leaf extract of *R. damascena* had the highest scavenging activity of 84.13% at the concentration of 250µg/mL while the leaf extract of *C. grandiflorum* had the lowest scavenging activity of 9.62% at the concentration of 50µg/mL. The scavenging activity was inversely proportional to the absorbance of sample (**Table 5** and **6**) (**Figure 3** and **4**).

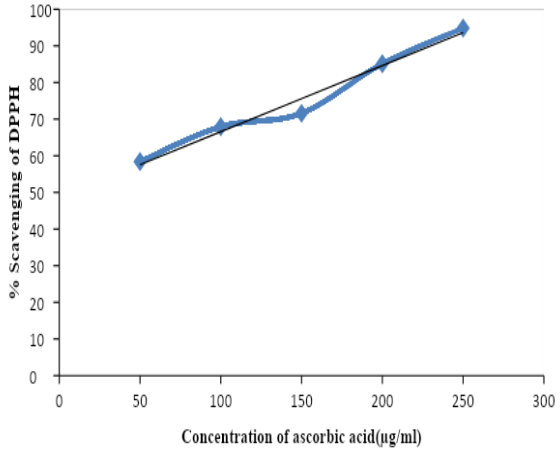

Figure 3. Regression trendline of % DPPH scavenging Vs concentration of extract of Ascorbic acid with IC_{50} value of 7.928 µg/mL.

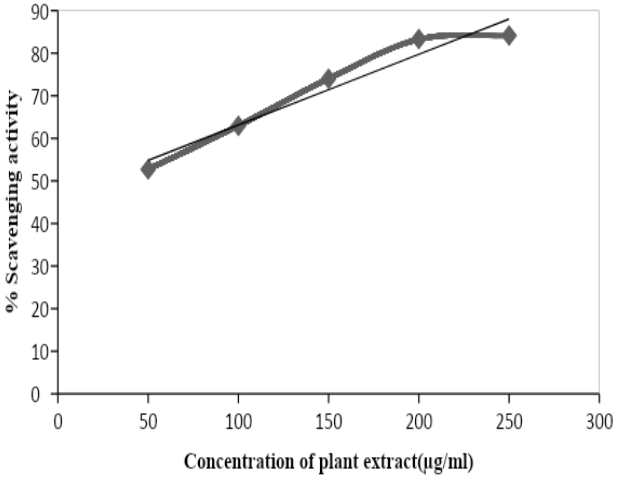

Figure 4. Regression trendline of % DPPH scavenging Vs concentration of leaf extract of *Rosa damascena.*

Discussion

The efficacy of conventional medications has declined in recent years, highlighting the need for the development of innovative, better-tolerated, and more effective therapies. Herbal treatments offer a viable alternative and complement to allopathic medical procedures, providing a potential solution to this challenge.

Phytochemicals, the bioactive compounds naturally present in plants, are well-known for their potential therapeutic effects, including antimicrobial and antioxidant properties. This study aimed to evaluate the phytochemical composition, antimicrobial, and antioxidant activities of twelve medicinal plants sourced from the Chitwan and Kathmandu districts of Nepal.

The phytochemical analysis of the plant extracts identified the presence of several bioactive compounds, including tannins, saponins, glycosides, flavonoids,

Table 5. % scavenging of DPPH by ascorbic acid and plant extracts

SN	Plants		% scavenging at different concentration (µg/mL)				
			50	100	150	250	200
1	*Rhododendron arboreum*	flower	48.97	54.12	58.67	61.58	63.26
		leaf	9.65	18.25	38.04	57	60.12
2	*Hibiscus rosa sinensis*	flower	50.86	65.44	75.04	79.42	83.54
		leaf	48.92	56.87	67.35	73.97	78.43
3	*Rosa damascena*	flower	42.22	55.52	68.31	77.14	79.11
		leaf	52.73	62.97	74.02	83.28	84.13
4	*Tagetes erecta*	flower	43.22	55.73	68.15	77.38	79.61
		leaf	37.93	41.87	48.65	56.75	64.12
5	*Bougainvillea glabra*	flower	37.11	56.43	64.42	73.51	78.02
		leaf	10.82	17.32	37.98	55.68	59.23
6	*Chrysanthemum grandiflorum*	flower	41.54	51	53.76	64.08	68.77
		leaf	9.62	18.12	31.12	39.36	53.05
Ascorbic acid			58.41	67.95	71.59	85.13	94.84

Table 6. IC_{50} value of ascorbic acid and different plant extracts

SN	Medicinal Plants	IC_{50} value(µg/mL)	
		Flower	Leaf
1	*Rhododendron arboreum*	48.43	197.90
2	*Hibiscus rosa sinensis*	18.53	50.77
3	*Rosa damascena*	74.21	21.10
4	*Tagetes erecta*	71.52	151.033
5	*Bougainvillea glabra*	89.84	200.99
6	*Chrysanthemum grandiflorum*	106.82	241.33
	Ascorbic acid	7.928	

alkaloids, and terpenoids, all of which are recognized for their biological activities. Tannins, polyphenolic compounds, have the ability to bind to proline-rich proteins, inhibiting protein synthesis and exhibiting antimicrobial effects. Flavonoids, which are polyphenolic compounds with hydroxyl groups, are produced by plants in response to microbial stress and have demonstrated antibacterial properties by interacting with bacterial cell walls and extracellular proteins. Terpenoids, widely known for their aromatic characteristics, also show significant antibacterial properties. Additionally, saponins, a class of glycosides known for their inhibitory effects on gram-positive bacteria such as *S. aureus*, were commonly found in the plant extracts [24].

The extraction yields varied significantly among the different plant samples. The highest yield was obtained from the flower extract of *R. arboreum* (23.15%), followed by *C. grandiflorum* flower extract (18.3%). The lowest yield was from the leaf extract of *T. erecta* (8%). These differences can be attributed to factors such as the plant type, the part of the plant used, extraction duration, the fineness of the powdered material, and its dryness level. Additionally, the use of solvents like methanol, ethanol, and other alcohols typically resulted in higher extraction yields, while aqueous extracts were less effective in extracting non-polar compounds [26].

In the antimicrobial test, only four flower and leaf extracts found to be effective against *S. aureus*. Rest of the samples didn't show any antimicrobial activity at the given concentrations. No extracts exhibited antibacterial property against *K. pneumoniae, P. aeruginosa* and *E. coli*. Several factors can influence these results, such as the environmental and climatic conditions where the plants were grown, the specific plant extracts chosen, the extraction method used, the type of antimicrobial testing, and the microorganisms selected for testing. Most of the samples were effective against *S. aureus*, which could be attributed to the extraction technique, the solvent employed, or the structural characteristics of the bacterial membrane. The extracts displayed stronger antibacterial activity against gram-positive bacteria, particularly *S. aureus*, compared to gram-negative bacteria. Gram-negative bacteria have a multi-layered structure, an outer membrane made of lipopolysaccharides, and a cell wall with a higher percentage of lipopolysaccharide, which makes it harder for the bacteria to interact with extracts [27].

Among the extracts evaluated, the flower extract of *R. arboreum* exhibited significant antimicrobial activity against *S. aureus*, with the largest inhibition zone of 10 mm at a concentration of 400 mg/mL. This finding is in line with the work of Kashyap et al. (2017) [28], who reported that ethanolic extracts of *R. arboreum* flowers were effective against *S. aureus*. However, the leaf extract of *R. arboreum* did not show any antibacterial effects against the tested bacteria, which contrasts with other studies where methanolic leaf extracts displayed inhibitory activity against a variety of bacterial strains. The flower extract of *T. erecta* also demonstrated

considerable antimicrobial efficacy against *S. aureus*, with a 15 mm inhibition zone at 400 mg/mL. This observation is consistent with the findings of Saani et al. (2018) [29], who reported the antibacterial effectiveness of methanolic *T. erecta* flower extracts against *S. aureus*, *E. coli*, *P. aeruginosa*, and *K. pneumoniae*. However, the leaf extract of *T. erecta* showed no activity against any of the tested bacteria. The flower extract of *R. damascena* was effective against *S. aureus*, with an inhibition zone of 20 mm at 400 mg/mL, aligning with Malik's (2020) study [30], which found that *R. damascena* flower extracts exhibited varying antibacterial activities against different bacterial strains. Although the leaf extract of *R. damascena* also showed some inhibitory effect on *S. aureus*, it was less potent than the flower extract. On the other hand, both the flower and leaf extracts of *Bougainvillea glabra* and *Chrysanthemum grandiflorum* did not display any antimicrobial activity against the organisms tested. This finding contradicts studies that reported antimicrobial properties of these plants' extracts. The discrepancies could be due differences in extraction methods, solvent types, and the specific strains of bacteria used in the tests [31].

The antioxidant potential of the plant extracts was assessed using the DPPH scavenging assay, with ascorbic acid serving as the reference standard. The leaf extract of *R. damascena* demonstrated the highest antioxidant activity, achieving 84.13% scavenging at 250 µg/mL, with an IC_{50} value of 21.10 µg/mL, indicating moderate antioxidant efficacy compared to ascorbic acid. The flower extract of *R. arboreum* also exhibited considerable antioxidant activity, with an IC_{50} value of 48.43 µg/mL, consistent with the findings of Kalauni et al. (2021) [32]. The flower extract of *Hibiscus rosa-sinensis* showed strong antioxidant properties, with an IC_{50} value of 18.53 µg/mL, while the leaf extract demonstrated moderate activity with an IC_{50} value of 50.77 µg/mL. The flower extract of *T. erecta* exhibited antioxidant activity, with an IC_{50} value of 71.52 µg/mL, and its leaf extract showed a higher IC_{50} value of 151.03 µg/mL, suggesting lower antioxidant potency. The flower extract of *Bougainvillea glabra* had an IC_{50} value of 89.84 µg/mL, while the leaf extract recorded an IC_{50} value of 200.99 µg/mL, reflecting lower antioxidant activity, aligning with the results of Saleem et al. (2020) [33] on *B. glabra*. The flower extract of *Chrysanthemum grandiflorum* had an IC_{50} value of 106.82 µg/mL, while the leaf extract showed a significantly higher IC_{50} value of 241.21 µg/mL, indicating weaker antioxidant activity.

Overall, our findings emphasize the promising potential of selected medicinal plants from Nepal as sources of phytochemicals with notable antimicrobial and antioxidant properties. Nevertheless, additional studies are required to better understand the mechanisms driving these effects and to refine extraction techniques for improved bioactivity. Furthermore, exploring the synergistic interactions between various plant extracts could pave the way for developing novel antimicrobial and antioxidant agents with enhanced effectiveness.

Conclusion

Phytochemical analysis of both flower and leaf extracts revealed the presence of various bioactive compounds, including alkaloids, flavonoids, anthraquinones, saponins, reducing sugars, glycosides, steroids, coumarin, and quinones. The extracts exhibited significant antioxidant activity, as indicated by their IC_{50} values, suggesting their potential as a source of antioxidant compounds. Additionally, both extracts exhibited significant antibacterial properties against *S. aureus*. Antioxidant activity increased with concentration, highlighting the concentration-dependent nature of scavenging activity. These results suggest that the plants investigated could be valuable, cost-effective sources of secondary metabolites, particularly for pharmaceutical applications Furthermore, their antimicrobial properties suggest they could serve as natural alternatives to synthetic preservatives in the food industry, offering a safer and more sustainable approach to food preservation.

Conflicts of Interest

The authors confirm that there are no conflicts of interest related to the publication of this paper.

Acknowledgements

The authors would like to express their gratitude to the Nepal Academy of Science and Technology and the Food Microbiology Laboratory at St. Xavier's College (Kathmandu, Nepal) for their support and for providing the essential research facilities that contributed to the successful completion of this study.

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