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Original Research Article

ANTI-INFLAMMATORY AND ANTICANCER POTENTIAL OF *SALSOLA KALI* L. AGAINST SKIN CANCER IN ALBINO RAT MODEL

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Abstract: *In the realm of cancer treatment, plants are offering effective curative compounds and most of the anticancer compounds have been obtained from the plants. Salsola kali* L. *is an important ethnomedicinal plant of the Chenopodiaceae family. In folkloric healthcare practices, it is being used to treat skin diseases. In the current study, plant extracts were prepared in solvents of different polarities through soxhlation and subjected to the detection of potential bioactive metabolites through Fourier Transform Infrared Spectroscopy and Gas Chromatography-Mass Spectrometry. The anti-inflammatory efficacy of plant extract was also determined through carrageenan and histamine assays. The anticancer potential of the plant was tested against the cancerous skin of albino mice. The studied plant had encouraging anti-inflammatory efficacy. The carrageenan percent inhibition occurred in a dose-response manner and peak edema volume reduction occurred at 4 hr. Findings of the carrageenan assay were also confirmed with the histamine assay. At 120 min maximum edema inhibition was detected and inflammation was reduced upto 65%. Animal study on rats, presented S. kali L. as a potential local biological resource for skin cancer treatment. Chemotherapy of animals with n-Hexane extract showed excellent results in curing benign lesions. Squamous cell carcinoma in situ and malignant fibrous hyperplasia were cured mildly, and malignancy progression did not occur. Plant extract's anticancer activity also coincided with the presence of potent bioactive compounds that were recorded in IR-spectra; triterpenoid and glycosidic saponins as O-H, C=O, C-H and C=C and C-O groups, respectively. Ethyl acetate also had good efficacy against the skin lesions. However, methanol extract showed less outcomes. GC-MS analysis of n-Hexane extract revealed the presence of an anticancer epoxide Cis-2.3-Epoxycotane. Ethyl acetate extract also showed the presence of an anticancer carbohydrate 1,6-Dideoxy-1-mannitol. These two anticancer compounds have been reported in the literature as having cancer-cure potential. Further, after cytotoxic analysis studied plant may be proven as a potential chemotherapeutic resource for skin cancer treatment.*

Keywords: Medicinal Plant; Phytochemicals; FTIR Analysis; GC-MS Analysis; Anti-Inflammatory Activity; Anticancer Activity

Introduction

Cancer is a group of life-threatening diseases and a second leading cause of death, globally. It can affect any tissue or organ of the body, and starts from the irregular proliferation and uncontrolled growth of abnormal cells in a specific location that results in mass formation termed as tumor. A unique microenvironment (nich) where cancer cells are found is the basic factor in the development of tumor. An essential element of tumor niche is inflammation. It is a natural response of living tissues immune system to any harm. Generation of reactive oxygen species (ROS) and fibrosis are major components of edema. If inflammation persists after wound has been healed, it can develop into chronic inflammation that stresses cells and damages them, which leads to the development of malignant mass. In inflammation, fibroblasts provide framework that connects tumor cells and supports growth. It also provide cell nutrition, cell communication, signal transduction and cell fate (Guo *et al*., 2016; Landen *et al.*, 2016). Therefore, treating inflammation is the initial course of action in cancer therapy (Hayes *et al.*, 2020). It has been proven that plants with high content of polyphenols also have a better capacity to reduce inflammation because these compounds have the ability to scavenge oxidation causing species (Kharel and Sharma, 2019).

Skin carcinogenesis is one of the major health risks around the globe. Pakistan is among the nations with an annual incidence of skin cancer that lies between 150 and 200 cases. It falls at ninth and eighth position in males and females, respectively. In addition to causing death, it puts financial, emotional and physical strain on families and healthcare systems (Sung *et al.*, 2021; PCR, 2017).

The novel anticancer drugs search was started long before (1950) and most of the cancer-treating agents (Vinblastine, vincristine, vinca alkaloids) have been either obtained or derived from natural sources (Zuo and Kwok, 2021). However, discovering a new therapeutic entity is not a simple and short-term task. It is a highly time-consuming, tedious and expensive process. In this journey, speed can be expedited by the adaptation of new approaches such as ethnopharmacology that not only shorten the route but also ensure safety and effectiveness. According to the Traditional Medicine (TM) Strategy 2014-2023 of WHO, primary sources of health care for many millions of people are traditional therapies, traditional doctors and

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herbal remedies (WHO, 2020). The use of ethnomedicines in international trade is significant, although different countries recognize different aspects of their medical and economic worth (Lamber and Oliveira, 2019).

A significant portion of the global population currently relies on herbal medications. In many countries, ethnomedicinal knowledge and practices have not been sufficiently utilized, researched or recorded. The future and present of community healthcare greatly depends on preserving medicinal plants (Paul *et al.,* 2022). According to Bechlaghem *et al.* (2019), plants in the Genus Salsola are a good source of antioxidants. Another study also claimed that skin diseases can be successfully treated with items created from halophytic plants (Jiratchayamaethasakul *et al.,* 2020). Patel (2016) found that plants cultivated in harsh environmental circumstances contain a considerable amount of phytocompounds. Due to the presence of phenols, flavonoids and other pharmacological components, they have the potential to treat cancer and inflammation (Rodriguez *et al*., 2017). However, the extraction solvents also have a profound effect on the efficacy of plant products (Bandara *et al.,* 2018).

Plants from disturbed and desert areas frequently being employed in folk medicines. Because they have significant amounts of alkaloids particularly tropane alkaloids, which are responsible for their medicinal effects. These alkaloids have antioxidant, anticancer and other properties (Al-Sanfi, 2018). Salsola is the largest genus of halophytic plants. It contains a large number of species, many of which are abundant in compounds having antioxidant properties due to the presence of polyphenols (ElNaggar *et al.,* 2022). *Salsola kali* L. is an important ethnomedicinal plant that is used to treat skin problems by the traditional healthcare practitioners of Southern Punjab, Pakistan. The current study was designed to determine the anti-inflammatory and anticancer potential of this plant using an albino rat model.

Methodology

Preparation of Extracts

Plant material dried away from sunlight, grounded into coarse powder and sieved (40 mm mesh). 200 ml distilled water was used to extract 30 gm finely ground material at 100°C. Then, fractionation was carried out using solvents of different polarities (n-Hexane, ethyl acetate and methanol). Extracts were processed under vacuum to remove solvents through rotational evaporation (Al-Amin *et al.,* 2019).

Fourier Transform Infrared Spectroscopy (FTIR) Analysis

Quantification of functional groups and their characteristic peaks in *S. kali* L. were performed through Shimadzu FTIR spectrophotometer (IRTracer-100, A217053, Shimadzu Corp. Japan) with ATR accessory and MCT detector in the spectral range 650–4000 cm−1. Saponins present in the plant extracts were also determined through functional groups because each category of saponins showed the presence of a specific functional group (Urbano *et al.,* 2006; Hemavathy *et al.,* 2019).

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

The plant extract was analyzed through GC-MS technique to investigate bioactive compounds. A single quadrupole gas chromatograph-mass spectrometer was used with standard non-polar column and the injection volume was 1.0 µl with a scan range of 1.5 to 1,000 m/z having scan interval of 0.5-2.0 u per second. 35 min was the total GC running time. The spectrum of unknown components of the plant sample was compared with the spectrum of known components stored in Wiley Special Library search programme NIST database. The names of components of the test material, molecular weight and structure were determined (Jyapriya and Shoba 2015).

Anti-Inflammatory Activity Assays

The efficacy of *S. kali* L. extracts was determined through carrageenan assay that was also confirmed with histamine assay. Percentage inhibition was calculated through following equation;

$$\textbf{Percent Edema Inhibition} = N.C - S.G/N.C \times 100$$

Where,
N.C = Negative control group, S.G = Sample group

Carrageenan Assay

Carrageenan was used to induce edema in right paw of Wister albino rats. Three sets of animals were created (seven rats per group): negative control (10 ml/kg of normal saline), standard drug (10 ml/kg of diclofenac potassium) and plant extract. Oral administration of standard drugs and plant extracts was conducted before 60 min carrageenan induction period.

Right paw of each rat was injected for edema induction with 0.1 ml (1%) carrageenan. With the help of plethysmometer, paw volume was measured after intervals (0 h, 1 h, 3 h and 9 h and 120 minutes) and calculated through above equation (Ismail *et al.,* 2017).

Histamine Assay

Each group of rats received 0.1 ml of histamine (1 mg/ml) under its left hind paw. Plant extracts and standard medication were given orally (p.o). Three sets of animals (seven rats per group) were used: negative control (normal saline), standard drug (chlorpheniramine maleate) and experimental group received plant extracts. Each rat received an injection of 0.1 ml (1 mg/ml) histamine to induce edema in its left paw. Paw volume was measured using a plethysmometer at 0, 1, 3, 9 and 120 min. The results were computed using Eq. 1 (Sajid *et al.,* 2017).

Anticancer Activity

5 to 6 weeks-old Wister albino rats were used in the experimentation. The rats were given synthetic rat meal and tap water at regular intervals (Mehmood, 2019).

Animals were acclimated for seven days, and dorsal skin of rats was clipped (5 × 5 cm) and marked before three days of experimentation (Osifo *et al.,* 2022). The group information for each rat was recorded at the start of experiment. Carcinogens were applied twice: once during

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the animal's resting hair cycle and once at night.

Experimentation

Rats were divided into 7 groups (A, B, C, D, E, F, G), based on controls and chemotherapy. DMBA (7-12-dimethyl benz (a) anthracene) was diluted in acetone (10 g/100 ml) to make 100 µg/mL solution and kept at 20°C. DMBA working solution was applied as a single dose of 100 µg/ml in groups B- G on the shaved dorsum of albino rats. After two weeks of DBMA application, TPA solution in acetone was given as l0 µg/ml twice a week in groups B-G for the first 15 weeks.

Group A animals were set as negative control and kept on a normal diet. Group B was disease control and only had the application of carcinogens. Groups C, D, E and F were vehicle controls (Acetone, n-hexane, Ethyl acetate and Methanol). Skin tissues of all animals were taken through line needle biopsy after 15 days. After the completion of 15 weeks carcinogen application was stopped. But for the next 15 weeks, animals of group B were kept under observation, and the effects of chemical complex carcinogens were seen in group B as the size and types of the tumor. However, the placebo and experimental groups received vehicle solvents and test drugs respectively. On completion of 30 weeks, all animals were anaesthetized and sacrificed. Required skin tissues were sampled immediately for histological observation. Chemical-complex carcinogen results were recorded as gross observations and lesions records.

Record of Lesions Particulars

Weekly loss of hair and other morphological features of tumor appearance were observed throughout the experiment. In the skin of each animal outgrowth and ulcer were counted and measured through Venires Caliper. On the completion of the experimental period, histopathological changes in lesions and surrounding skin of each animal such as atrophy, hyperplasia, parakeratosis, dysplasia, fibrosarcoma, chronic inflammation, squamous cell carcinoma in situ, extensive squamous cell carcinoma and osteoma etc. were examined microscopically after staining with haematoxylin and eosin stains. According to the histopathological observation classification of lesions was also performed.

Histological Analysis

After 30 weeks, all animals were anesthetized and sacrificed. A longitudinal section was taken following re-sectioning. Cancerous and surrounding tissues were washed 2-3 times with saline solution then processed dorsal skin specimens were fixed in labelled jars with 10% formalin (Bugshan *et al.*, 2022). After 24 hr of fixation, all tissues were examined in the glossing room. All the specimens were processed in an enclosed type of automated processing system (Spencer *et al.*, 2012).

After 24 hr of preparation, tissues were embedded using a conventional Lockhart's "L" piece receptacle. Blocks of paraffin wax were made and further solidified by being stored in the refrigerator. On a rotating microtome, prepared blocks were positioned, and pieces were cut using a simple, sharp wedge blade. Flat sections were created by aligning the section ribbons properly. Flat parts were carefully picked up and put on glass slides. Sections of the tissues were positioned on slides, then albumin was used to bind them together after they had been hydrated by being submerged in the thermostatically controlled water bath (Nayak, 2018).

Haematoxylin-Eosin-Staining Protocol

After using progressively lower grades of alcohol (100% & 70%) and water hydrations, pieces were dewaxed by dipping them in xylene. Slides were then gradually immersed in Harris Haematoxylin for 10 min to more clearly stain the nucleus. Acetic acid-alcohol rinse for 10 seconds was followed by 5 min of running tap water to eliminate excess strain from slide and tissues. Eosin (1%) was used to stain the sample for 10 min followed by 5 min of washing under running water. After xylene rinsing tissues were mounted in Canada balsam, the stained sections were dehydrated with alcohol in progressive grades (50, 70, 90 and 100%) (Suvarna *et al.*, 2013).

Statistical Analysis

The anti-inflammatory activity of the plant was analyzed through Microsoft Excel (2016). Anticancer activity data of plant extracts were analyzed using SPSS software (V. 16). Using same statistical criteria, responses to chemical-complex with topical chemotherapy were demonstrated in all experimental groups and two-way analysis of variance was applied (ANOVA) setting significance value $p<0.05$.

Results

S. kali L. extracts obtained in different solvents (n-hexane, ethyl acetate and methanol) were analyzed for bioactive compounds and tested for their medicinal applications.

Fourier Transform Infrared Spectroscopy (FTIR) Analysis

Using Fourier transform infrared spectroscopy (FTIR) analysis, the leaves and stem extracts prepared in various solvents (non-polar to polar) were examined for the presence of functional groups and surfactants to determine which solvent was best for extracting saponins. By matching the compound's spectra with the accessible IR-Spectrum Library, the compounds were identified. Significant amounts of saponins were found in the plant extracts that was represented as triterpenoid saponins (O-H, C=O, C-H and C=C) and glycosidic saponins (C-O). The concentration of saponins in the extracts was occurred as; n-Hexane < Methanol < Ethyl acetate.

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

A variety of bioactive substances were found in *S. kali* L. through GC-MS analysis. Retention time, molecular formula, intensity, molecular weight, chemical structure and biological activities of chemicals detected in plant are enlisted in Table 1.

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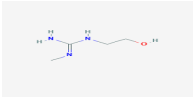
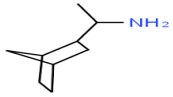
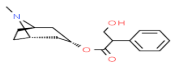
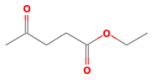
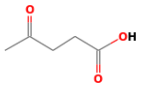
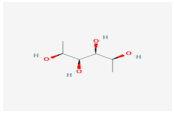
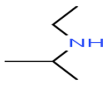
Table 1: Major compounds identified through GC-MS analysis

Name of Compounds	Retention Time	Molecular Formula	Intensity	Molecular Weight	Structure	Category	Biological Activities
Cis-2.3-Epoxycotane	1.470	$C_8H_{16}O$	40.85	128		Epoxide	Cancer Treatment
2-(3-Methylguanidino) Ethane	1.470	$C_4H1_1N_3O$	40.85	117		Amide	Treat Muscle weakness and tiredness
1-(5-Biscyclo[2.2.1]heptyl) Ethylamine	17.025	$C_9H_{17}N$	44.00	139		Alkaloid	Antiamoebic activity (Fadhil *et al.*, 2021)
2-Decenal, (E)	4.815	$C_{10}H_{18}O$	42.10	154		Aldehydes	Kill nematodes (Caboni *et al.*, 2012)
Hyoscyamine	17.025	$C_{17}H_{23}NO_3$	124.10	289		Tropane alkaloid	Gastrointestinal Treatment (Manpreet *et al.*, 2017)
1,6-Dideoxy-1-mannitol	1.410	$C_6H_{14}O_4$	42.85	150		Carbohydrate	Palpable tumor Treatment (Balo *et al.*, 1959)
Pentanoic acid, 4-oxo-	1.673	$C_5H_8O_3$	43.05	116		Keto acid	Antiseptic (Song *et al.*, 2015)
1-(5-Bicyclo[2.2.1]heptyl) ethylamine (Norbornane)	1.380	$C_9H_{17}N$	44.05	139		Indole Alkaloid	Antibacterial, antiviral, Anti-Inflammatory Activity (Al-Mosawi & Al-Saily, 2021
2-Isopropoxyethylamine	2.587	$C_5H_{13}NO$	45.05	103		Ethylisopropylamine	Treat infections (Sharmila *et al.*, 2021)

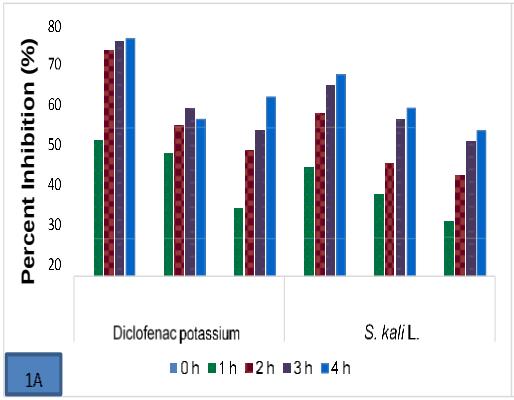


Figure 1A: % inhibition of inflammation in carrageenan assay at different time intervals

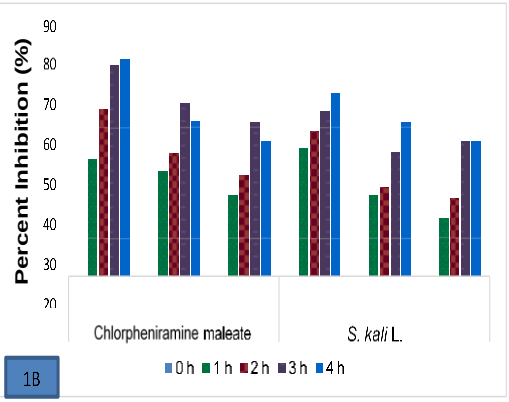


Figure 1B: % inhibition of inflammation in histamine assay at different time intervals

Table 2: Lesions observed in experimental animals treated with n-Hexane extract (G1) after applying experimental protocol

Sr. No.	Wt. (g)		Gross Examination			Microscopic Examination			Diagnosis	Protection
	Before	After	Ulcer	Mass	Other	Epidermis	Dermis	Other		
1	162	110	Nil	Nil	Nil	EHP	ED	Ac.Inf	HP	Mild Protected
2	152	107	Nil	Nil	Nil	EHP	ED	Ac.Inf	HP	Mild Protected
3	153	118	Nil	Nil	Nil	EHP	FB	Ac.Inf	DYS+PAP	Mild Protected
4	172	269	+	Nil	Nil	EHP	FB	Ac.Inf	HP	Mild Protected
5	125	96	Nil	Nil	Nil	EHP	NOR	Ac.Inf	MUL+HP	Less Protected
6	151	116	Nil	Nil	Nil	EHP	FB	Ac.Inf	HP	Mild Protected
7	137	251	Nil	Nil	Nil	EHP	ED	Ac.Inf	MUL+HP	Mild Protected
8	164	234	Nil	Nil	Nil	EHP	NOR	Ac.Inf	MUL+HP	Mild Protected
9	154	228	Nil	Nil	Nil	EHP	ED	Ac.Inf	HP	Mild Protected
10	166	230	Nil	Nil	Nil	EHP	NOR	Ac.Inf	MFH	Mild Protected

NOR- Normal
HIC- Histiocytoma
Ac-Inf- Acute infection
SCI-Severe chronic infection
SQCC- Squamous Cell Carcinoma
CCIS- Severe chronic infection
HP- Hyperplasia
DYS- Dysplasia
PAP- Papilloma
SCB- Scab formation
EHP-Epidermal Hyperplasia
LH- Loss of Hairs
MUL- Multiple
FB-Fibrosis
MFH- Malignant fibrous histiocytoma
OT- Ostema
Bony Osts - Bony Ostema
ED- Edema

Table 3: Lesions observed in experimental animals treated with ethyl acetate extract (G2) after applying experimental protocol

Sr. No.	Wt. (g)		Gross Examination			Microscopic Examination			Diagnosis	Protection
	Before	After	Ulcer	Mass	Other	Epidermis	Dermis	Other		
1	9	271	Nil	Nil	Nil	EHP	FB+ED	Ac. Inf	MUL+HP	Mild Protected
2	165	232	Nil	Nil	LH+Scl	EHP	MFH	Bony Osts	MFH	Less Protected
3	152	265	Nil	Nil	Nil	DYP	ED	Ac. Inf	HP	Mild Protected
4	143	254	Nil	Nil	Nil	HP+PAP	ED	Ac. Inf	MFH	Mild Protected
5	167	243	Nil	Nil	Nil	PAP	OT	Ac. Inf	DYS+PAP	Mild Protected
6	185	DEAD	Nil	Nil	Nil	EHP	FB	Ac. Inf	MUL+MFH	Mild Protected
7	145	256	Nil	1mm	LH.Sc	EHP	ED	Ac. Inf	MUL+HP	Less Protected
8	174	251	Nil	Nil	Nil	EHP	NOR	Ac.Inf	MFH	Mild Protected
9	164	234	Nil	Nil	Nil	EHP	ED	Ac. Inf	MUL+HP	Mild Protected
10	143	228	+	Nil	Nil	EHP	ED	Ac. Inf	DYS+PAP	Mild Protected

NOR- Normal
SCI-Severe chronic infection
HP- Hyperplasia
SCB- Scab formation
MUL- Multiple
OT- Ostema

HIC- Histiocytoma
SQCC- Squamous Cell Carcinoma
DYS- Dysplasia
EHP-Epidermal Hyperplasia
FB-Fibrosis
Bony Osts - Bony Ostema

Ac-Inf- Acute infection
CCIS- Severe chronic infection
PAP- Papilloma
LH- Loss of Hairs
MFH- Malignant fibrous histiocytoma
ED- Edema

Table 4: Lesions observed in experimental animals treated with methanol extract (G3) after applying experimental protocol

Sr. No.	Wt. (g)		Gross Examination			Microscopic Examination			Diagnosis	Protection
	Before	After	Ulcer	Mass	Other	Epidermis	Dermis	Other		
1	171	364	Nil	Nil	Nil	PAP	FB	Ac.Inf	PAP	Mild Protected
2	162	275	Nil	Nil	LH+Scl	PAP	FB	Ac.Inf	SQCC	Mild Protected
3	175	328	Nil	Nil	Nil	EHP	EB	Bony Osts	HP	Mild Protected
4	153	269	Nil	Mul 1mm	LH.Sc	HP+PAP	ED	Ac.Inf	MFH	Less Protected
5	172	118	Nil	Nil	Nil	EHP	FB	Bony Osts	DYS+PAP	Less Protected
6	185	328	Nil	Nil	Nil	EHP	NOR	Bony Osts	HP	Mild Protected
7	174	350	Nil	Mul 1mm	LH.Sc	EHP	ED	Ac. Inf	MUL+HP	Less Protected
8	137	251	Nil	Nil	Nil	EHP	ED	Ac.Inf	HP	Mild Protected
9	164	324	Nil	Nil	Nil	EHP	ED	Ac.Inf	MUL+HP	Mild Protected
10	135	248	Nil	Nil	Nil	PAP	FB	Bony Osts	PAP	Mild Protected

NOR- Normal
SCI-Severe chronic infection
HP- Hyperplasia
SCB- Scab formation
MUL- Multiple
OT- Ostema
HIC- Histiocytoma
SQCC- Squamous Cell Carcinoma
DYS- Dysplasia
EHP-Epidermal Hyperplasia
FB-Fibrosis
Bony Osts - Bony Ostema
Ac-Inf- Acute infection
CCIS- Severe chronic infection
PAP- Papilloma
LH- Loss of Hairs
MFH- Malignant fibrous histiocytoma
ED- Edema

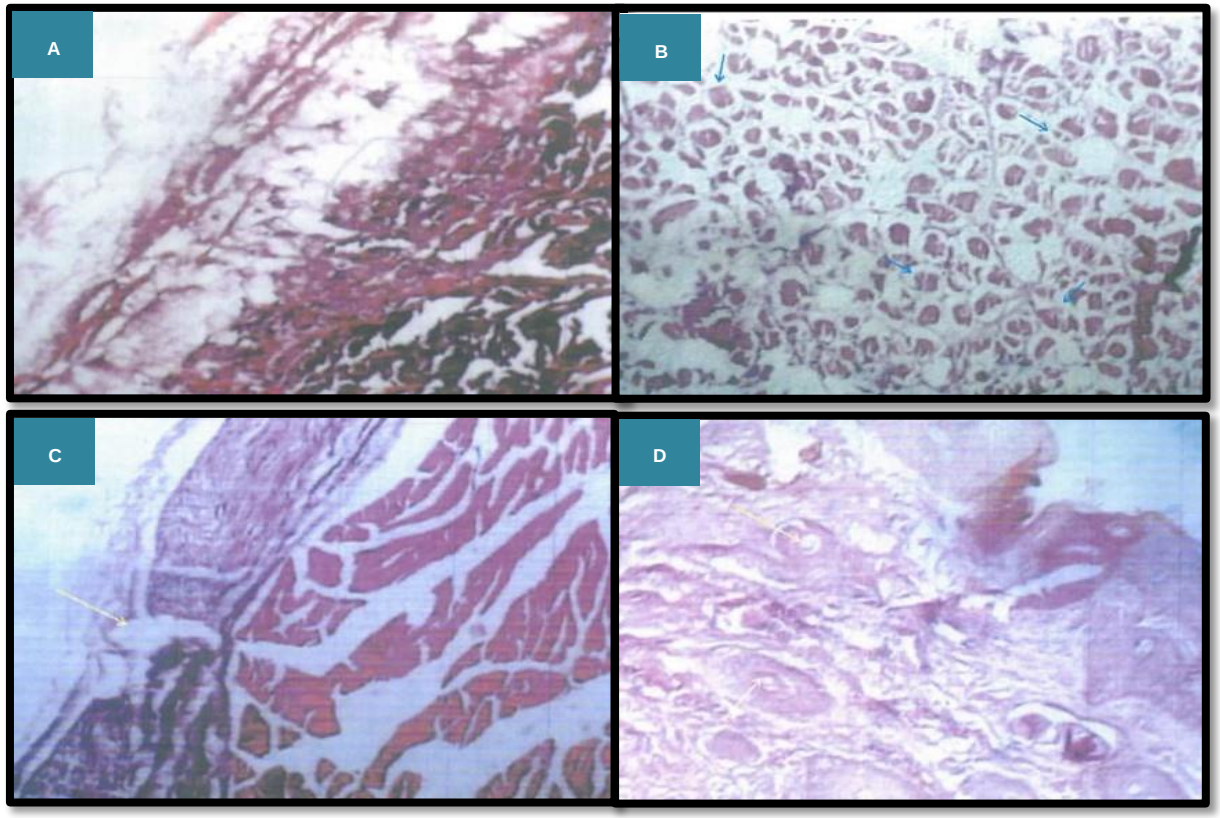


Figure 2: Histological evaluation demonstrated the healing effects observed at the end of experimentation.

A-Normal skin, B-Skin cancer mitotic stage, C-In situ carcinoma, D-Skin vacuolation

Discussion

Medicinal plants have played a significant role in global health from the beginning. As many hazardous diseases can be cured with medicinal plants, the demand for herbal medicines is rising steadily. Currently, due to the ineffectivity and adverse effects of the available drugs it has also become necessary for the manufacturers to synthesis new pharmaceuticals, which has put pressure on the pharmaceutical industry to provide novel medicines (Saleem *et al.,* 2020).

The studied plant has been valued as a key source against inflammation through carrageenan and histamine testing, and effect was occurred in dos-dependent manner (see Figures 1A & 1B). The results of histamine and carrageenan assays were comparable to those of common anti-inflammatory medications diclofenac potassium and chlorpheniramine maleate, respectively. Additionally, a prior study also demonstrated that plant ability to reduce inflammation increased as plant extract concentration rose. The duration of observation following the administration of plant extracts was also strongly correlated with the time of observation that was also documented in a previous study (Ismail *et al.,* 2017). According to Javed and Jabeen (2021), Salsola plant had significant anti-inflammatory effect through the reduction of pro-inflammatory proteins and tumor necrosis factor in a dose-dependent manner. A previous study has reported that in degenerative and chronic diseases, oxidative stress is a major causative factor. Folkloric plants have a significant quantity of phenolic compounds that have a direct link with their anti-inflammatory activity (Kefayati *et al.,* 2017). Rutkowska *et al.* (2020) has also reported that Salosla plants having a considerable concentration of such bioactive phytochemicals that can efficiently reduce reactive oxygen species in the edema.

Skin is the largest organ of body that protects from noxious agents and environmental stresses. When the stress agents pile up, skin degeneration occurs and progresses in the form of lesions formation. Skin cancer is one of the most serious types of cancer. The two most prevalent kinds of skin cancer are squamous cell carcinoma and basal cell carcinoma. Reduction in inflammation and precancerous cells are crucial steps in the inhibition of skin cancer development. In the current study, good activity for reducing inflammation, fibrosis and cancer was revealed by *S. kali* L. and its anticancer characteristics against the topical tumor activity were very encouraging. According to a previous study, the major indicators of establishing a malignant mass are the buildup of oxidizing agents and cell-escape from apoptosis (Ng *et al.,* 2018). Quantification of plant's bioactive metabolites revealed a substantial relationship between anti-inflammtion activity, tumor angiogenesis, apoptosis and suppression of cancer proliferation that was also documented in previous studies. Plants rich in polyphenols have significant anti-inflammatory and anti-proliferative potential (Al-Dabbagh *et al.,* 2018).

In the treatment of skin diseases selected biological resource (*S. kali* L.) is an ethnopharmacologically important plant and it is a possible potential drug candidate for the treatment of skin cancer. The anticancer activity of *S. kali* L. coincided with the quality of extracts in the context of bioactive components. Among others, n-Hexane extract was excellent in the healing of skin lesions (see Tables 2, 3 & 4). The efficacy order of the anticancer of the studied plant extracts was < n-Hexane < ethyl acetate < methanol. It has also been reported that salt stress in the plant environment caused the synthesis of various plant bioactive compounds to cope with the stressed circumstances as a resilient and adaptable behavior (Acosta-Motos *et al.,* 2017). It was also revealed in a recent study on dried-region plant's alkaloids (such as atropine) that these substances were created as a reaction to abiotic stressors in the plant environment and were highly useful in treating cancer (Punetha *et al.,* 2022). Detection of triterpenoid and glycosidic saponins also supported the anticancer effect of the plant. Saponins gaining attention in recent years for cancer therapy. They are highly complex phytocompounds and adopt multiple mechanisms in cancer treatment such as antioxidant action, cycle arrest, inhibition of cellular invasion, autophagy, cell apoptosis and anti-angiogenesis activities through suppressing gene expression involved in VEGF and HIF-1alpha release and activation. Saponins also inhibit pro-inflammatory cytokines (COX-2, TNF-alpha and IL-6) genes expressions (Majnooni *et al*., 2023). Evidences shows that saponins prevent and treat cancer through migration and tumor cell differentiation induction (Tian *et al*., 2020; Chen *et al*., 2018; Liu *et al*., 2022). GC-MS analysis also showed the presence of anticancer compounds in plant (Cis- 2.3-Epoxycotane-n-Hexane extract and 1,6-Dideoxy-1-mannitol-ethyl acetate extract) that supports its anticancer potential (see Table 1). The necessity for finding innovative medicinal chemicals with anti-inflammatory and anticancer properties has increased due to the growing burden of diseases on the society (Greenwell and Rahman, 2015). In this scenario, herbs having medicinal potential have been receiving more attention from the pharmaceutical research community.

Conclusion

Salsola kali L. is an important folkloric and less-explored Salsola plant of Pakistan. The current study reports on its bioactive compounds with anti-inflammation and anticancer efficacy that makes a significant contribution and provides scientific proof of its traditional value. Based on natural pharmaceuticals, the studied plant is also a quite optimistic about finding possible chemotherapeutic agents for inflammation and skin cancer chemotherapy.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department Concerned.
Consent for publication
Approved
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Not applicable

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Conflict of interest

The authors declared absence of conflict of interest.

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