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Phytochemical diversity, ethnomedicinal and therapeutic potential of the Genus *Verbesina*: A concise review

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ABSTRACT: The exploration encompasses the diverse dimensions of the *Verbesina* genus, a cluster of flowering plants within the Asteraceae family, comprising 340 species with varied growth patterns and floral attributes. Traditional medicinal practices associated with *Verbesina* species across different cultures are scrutinized, emphasizing the necessity for scientific validation of these ethnomedicinal traditions. Through chemical and pharmacological profiling, *Verbesina* plants reveal a plethora of bioactive compounds and therapeutic potentials, propelling opportunities for drug discovery and development. Safety considerations, conservation challenges, and sustainable harvesting practices emerge as pivotal factors in maximizing the benefits of *Verbesina* species while minimizing environmental impacts. Finally, we underscore the significance of collaborative research efforts, recognizing the invaluable contributions of our professional colleagues and researchers in related fields, in fully harnessing the medicinal, healthcare and conservation potentials of *Verbesina* plants, promising groundbreaking discoveries and applications with profound implications for human well-being.

Keywords: *Verbesina*; ethnopharmacology; phytochemistry; medicinal value.

1. Introduction

The genus *Verbesina* encompasses a diverse group of flowering plants within the Asteraceae family, commonly known as the sunflower family. The *Verbesina* genus currently comprises of 340 species. Including both annuals and perennials (shrubs, trees), numerous species possess a somewhat weedy nature, regularly reseeding themselves, and feature flowers rich in nectar (WFO, 2024). The genus displays considerable diversity in its growth habits. While certain species manifest as trees within montane moist or cloud forests, most adopt a shrubby form across various montane tropical vegetation assemblages (Panero and Strother, 2021).Each species within the genus exhibits flowers in shades of white or yellow, resembling miniature sunflowers. The term "*Verbesina*" is likely derived from the resemblance of its foliage to that of the unrelated *Verbena* (Merriam-Webster, 1828). In *Verbesina*, the capitula (a racemose inflorescence in the form of a disc of sessile flowers, the youngest at the centre, occurs in the daisy and related plants) can take on both a discoid or radiate form, and the prevailing corolla colors are predominantly golden yellow or white. However, a limited number of species exhibit

corollas in shades of red, orange, green, cream-colored, light yellow, and occasionally pink. *Verbesina* is distinguishable from Heliantheae by its distinctive biconvex fruits featuring mostly symmetrical wings and a pappus characterized by two awns without intervening squamellae(Panero and Strother, 2021). The majority of *Verbesina* species are perennials, such as *V. alternifolia*, *V. aristata*, *V. chapmanii*, *V. dissita*, *V. helianthoides*, *V. heterophylla*, *V. lindheimeri*, *V. longifolia*, *V. nana*, *V. occidentalis*, *V.* In traditional medicine practices, *Verbesina* species are documented for internal use in treating gastrointestinal disorders and externally for alleviating conditions such as rheumatism and hemorrhoids. Phytochemical studies have unveiled the isolation and characterization of more than 200 compounds within the genus. Terpenoids emerge as the most prevalent secondary metabolites, followed by aromatics, flavonoids and alkaloids. Sesquiterpenoids are the most abundant within the terpenoid category, reported in most species within this genus. A limited number of species have undergone pharmacological investigations(Mora *et al.*, 2013b).

2. Traditional Healing Wisdom: Ethnomedicinal uses of *Verbesina* species across different cultures

The genus *Verbesina* includes a variety of flowering plants, and some species within this genus have been traditionally used in ethnomedicine for various purposes. It's important to note that the specific uses may vary among different cultures, and not all species within the genus may have documented ethnomedicinal uses. It's crucial to highlight that while there may be ethnobotanical and ethnomedicinal knowledge associated with certain *Verbesina* species, scientific validation is necessary to confirm these traditional uses and to understand the safety and efficacy of these plants for medical purposes. Additionally, the specific species within the genus *Verbesina* and their uses can vary, so it's essential to refer to local traditional knowledge and practices for accurate information (Table 1). Here are some general ethnomedicinal uses associated with specific *Verbesina* species:

Table 1: Ethnomedicinal uses of genus *Verbesina*

Verbesina species	Plant part	Mode of preparation (application)	Traditional uses	Country (Refs.)
V. abscondita	Wp	Ex (p.o.)	Respiratory tract illness	Mexico (Cilia-López *et al.*, 2021)
V. crocata	Lf and Fw		Anti-diabetic, diuretic, diaphoretic, cathartic, antipyretic, astringent, aphrodisiac effects, and dermatological conditions	Mexico (Pérez G *et al.*, 1984, Alonso-Castro *et al.*, 2011)
	Ap	Dec (top.)	Wounds, burns and sore throats	Mexico(Canales *et al.*, 2005)
		Inf (p.o.)	Anti-tussive	Mexico (Waizel-Bucay and Waizel-Haiat, 2009)
	Lf		Renal disorders	Mexico (Heyerdahl-Viau *et al.*, 2023)
V. encelioides	Wp	Dec (top.)	Arthritis, rheumatism	Colorado(Bye and Linares, 1986)

			Spider bites, snake bites, and warts	India(Jain *et al.*, 2008)
	Lf	Ex (p.o.)	Gastrointestinal problems	Pakistan(Ayub *et al.*, 2023)
			Laxative	India(Parrotta, 2001)
		---	Ophthalmic problems	Argentina(Trillo *et al.*, 2010)
V. gigantea	Wp		Anti-malarial	Belize (Milliken *et al.*, 2021)
	Rt	Dec (top.)	Snake bites	Colombia(Vásquez *et al.*, 2015)
V. helianthoides	Wp	Dec (p.o.)	Cystitis and urinary stones	Geogia(Treben, 2007)
V.macrophylla		Ex (p.o.)	Renal infections and fever	Mexico (Deiró *et al.*, 2023)
	Lf	Dec (p.o.)	Renal and urethral infections	Brazil (Moreira *et al.*, 2002)
	Fw		Inflammation	Brazil (Agra *et al.*, 2007)
V. nergensis	Wp	Dec (top.)	Antiseptic in wounds	Mexico(Mora *et al.*, 2013b)
V. persicifolia			Antiseptic in wounds	Mexico(Jerezano Alberto *et al.*, 2016)
	Ap	Ex (p.o.)	Gastric cancer, gastrointestinal disorders, and inflammatory conditions; anti-diabetic and diuretic	Mexico (Pérez G *et al.*, 1984, Alonso-Castro *et al.*, 2011)
	Lf	Inf (top.)	Fever	Mexico(Josabad Alonso-Castro *et al.*, 2012)
V. scabra			Antiseptic in wounds	Argentine Northwest (Salazar-Gómez and Alonso-Castro, 2022)
V. sphaerocephala	Ap	Dec (top.)	Ulcers and gynecological conditions	Mexico (Jerezano Alberto *et al.*, 2016, Velasco-Ramírez *et al.*, 2019)
V. tetraptera			Dermatological illnesses and eczema	Mexico (Weimann and Heinrich, 1997)
V. turbacensis	Wp	Ex (p.o.)	Gastrointestinal disorders	Mexico(Mora *et al.*, 2013b)
	Lf	Dec (top.)	Wounds washes	Mexico (Martínez-Hernández *et al.*, 2022)
V. virginica	Rt	Dec (p.o.)	Diuretic and against uterine weakness	Chickasaw Indians (Campbell, 1951)

			Diuretic and laxative	Mexico(Mora *et al.*, 2013b)

3. Chemical and Pharmacological Profiling of *Verbesina*: Implications for Drug Discovery and Development

The genus *Verbesina*, a diverse array of flowering plants within the Asteraceae family, has long been a subject of interest for researchers and traditional healers. With over 340 species identified to date, *Verbesina* species have been a source of fascination due to their wide-ranging medicinal properties. This genus is a rich source of bioactive compounds, including alkaloids, flavonoids, terpenoids, sesquiterpenes, and fatty acids, distributed across various plant parts. From centuries of traditional use to contemporary scientific investigations, *Verbesina* plants have emerged as promising drug discovery and development candidates. By systematically profiling the chemical constituents and pharmacological actions of *Verbesina* species, researchers aim to uncover novel therapeutic agents to address unmet medical needs. The table- 2 explores the intricate interplay between *Verbesina* plants' chemical diversity and pharmacological activities, highlighting their potential applications in modern medicine and pharmaceutical innovation, offering a beacon of hope for future medical advancements.

Table 2: Chemical and Pharmacological Literature review of Genus *Verbesina*

Verbesina species	Parts	Extract (s) / compound(s)	Class of compounds	Pharmacological action	Refs.
V. alternifolia	Fw	---	ALK, STR, FLA	---	(Solanki *et al.*, 2021)
V. boliciana	Rt	Ethyl 3,4-dihydroxycinnamate	-		(Bohlmann *et al.*, 1980)
	Ap	linoleic and linolenic acid	FA		
V. caracasana	Wp	MeOH / Caracasanamide, caracasandiamide	---	Anti-hypertensive	(Delle Monache *et al.*, 1996)
		MeOH / N^3-prenylagmatine, N^1-3',4'-dimethoxycinnamoylagmatine, agmatine and galegin (prenylguanidine			(Monache *et al.*, 1999)
	Lf	MeOH / (Z)-Caracasanamide			(Delle Monache *et al.*, 1993)
		MeOH / (3,4-Dimethoxycinnamoyl)-N1-agmatine A			(Carmignani *et al.*, 2001)
V. cinerea	Rt	borneol coumarate and ferulate	TER	---	(Bohlmann *et al.*, 1980)
	Ap	Germacrene D	GD		
V. crocata		MeOH	---	Wound healing	(García-Bores *et al.*, 2020)
		Aq		Diuretic	(Salazar-Gómez *et al.*, 2018)

V. diversifolia	Lf	β –caryophyllene, bicyclogermacrene and germacrene D-4-ol	EO	-	(Albuquerque *et al.*, 2006)
V. encelioides	Wp	HA / Galegine /3-methyl-2-butenylguanidine	ALK		(Eichholzer *et al.*, 1982)
		PE/ Taraxasterol acetate	TER	Anticancer (hepatocarcinoma Hep G2 cell lines), Antibacterial (S.A., B.S., and E.C.), antifungal (A.F. and C.A.)	(Abbas *et al.*, 2016)
		PE/ β-amyrin	TER	---	(Abbas *et al.*, 2016)
		PE/ β-sitosterol and stigmasterol	STR		
		EtAc / Stigmasterol-3-O-β-D-glucopyranoside	STR-SAP		
		EtAc / p-coumaric acid	PHE		
		EtAc / Hyperoside (Quercetin-3-O-β-D-galactopyranoside)	FLA		
		EtAc / Galegine	ALK	Antibacterial (B.S., S.A. and E.C.), antifungal (A.F. and C.A.)	
		MeOH	---	Antibacterial (S.A., and E.C.)	(Gouda *et al.*, 2014)
				Anticancer (hepatocarcinoma Hep G2 and breast cancer MCF-7 cell lines)	(Al-Oqail *et al.*, 2016)
			ALK, FLA, SAP, TAN	---	(Chauhan and Rijhwani, 2015)
		EtOH	---	Antiviral (Coxsackie, Enterovirus C (polio), herpes simplex, measles (rubeola) and Semliki Forest virus)	(Jain *et al.*, 1988)
		CHCl3, EtAc and n-Hexane	ALK, FLA, SAP, TAN	---	(Chauhan and Rijhwani, 2015)
	Ap	MeOH	---	Anticancer (breast MCF7 and cervix	(Almehdar *et al.*, 2012)

				cancer HELA cell lines)	
			ALK, FLA, STR, TAN	Anticancer (breast MCF7, Non-small-cell lung NCI-H460 and CNS cancer (glioblastoma) SF268 cell lines)	(Albalawi *et al.*, 2015)
			ALK, FLA, GLY	Antibacterial (S.A., E.C., and C.V.)	(Singh and Dahiya, 2017)
			---	Antiprotozoal (L. I., P.F., T.B., and T.C.)	(Abdel-Sattar *et al.*, 2010)
		EtOH		Anticancer (colon HCT-116 cell lines)	(Farshori, 2021)
				Antiviral (Coxsackieand measles (rubeola) virus)	(Jain *et al.*, 1988)
		Acetone	ALK, FLA, GLY, SAP, STR, TER	---	
		CHCl3	FLA, GLY, STR, TER		
		PE	FLA, STR, TER		
		PE/ α-, β-amyrins and taraxasterol acetate	TER		(Joshi, 1983)
		PE/ Benzyl-2, 6- dimethoxy benzoate	O-methoxybenzoic acid derivatives		
		PE/ Bornyl ferulate	PHE		
		PE/ Linoleic acid, linolenic acid	FA		
		PE/ Phytol	TER		
		PE/ Stigmasterol	STR		
		PE/ Pseudotaraxasterol-3β-acetate	TER	Antiprotozoal (L. I., P.F., and T.B.)	(Ezzat *et al.*, 2017)
		PE/ 16β-hydroxy-pseudotaraxasterol-3β-palmitate	TER	Antiprotozoal (L. I.)	
		PE/ Pseudotaraxasterol	TER	Antiprotozoal (T.C.)	
		PE/ β-sitosterol glucoside and β-sitosterol galactoside	STR - GLY	-	
	Lf	Aq	---	Antibacterial (E.C., and V.C.)	(Kushwaha and Malik, 2012)
			AgNPs	Antibacterial (E.C., and V.C.);	

				antifungal (A.F., and A.N.)	
			FLA, PHE,TAN, TER	---	(Kaur *et al.*, 2021)
			---	Nematicidal activity (*Meloidogyne javanica*, *Tylenchulus semipenetrans*)	(Oka, 2012)
		Aq / Soluble Proteins		Antibacterial (S.A., S.C., P.A., E.C., E.F.) and antifungal (A.F., F.O., R.S.)	(Ramakrishnan *et al.*, 2017)
		EtOH / Quercetin 3-galactoside, quercetin-3-galactoside-7-glucoside and quercetin-3-xyloside-7-glucoside	FLA	---	(Glennie and Jain, 1980)
	St	Aq	---	Antibacterial (E.C., and V.C.)	(Kushwaha and Malik, 2012)
			AgNPs	Antibacterial (E.C., V.C.) ; antifungal (A.F., A.N.)	
			ALK, ATQ, CHO, FLA, GLY, PHE, TAN, PRT, TER	---	(Kaur *et al.*, 2021)
			---	Nematicidal activity (*Meloidogyne javanica*, *Tylenchulus semipenetrans*)	(Oka, 2012)
	Fl		ALK, ATQ, CHO, FLA, GLY, PHE, TAN, PRT, TER	---	(Kaur *et al.*, 2021)
			---	Nematicidal activity (*Meloidogyne javanica*, *Tylenchulussemipenetrans*)	(Oka, 2012)
		MeOH		Antibacterial (E.C., and K.P.)	(Jain *et al.*, 2007)
				Antibacterial (S.A., S.E., S.I.,	(Toribio *et al.*, 2005)

				P.A., S.A., S.T., C.F., E.C.) and antifungal (C.A.)	
		HA	SAP	Antioxidant	(Verma *et al.*, 2019)
			SAP conjugated-AgNPs	Anti-acne (*Propionibacterium acnes*)	
		EtOH / Galegine /3-methyl-2-butenylguanidine	ALK	Hypoglcemic	(Jain *et al.*, 1988)
		EtOH	EO enriched fractions	Antibacterial (E.C., and S.F.); antifungal (A.F., and F. M.)	
			STR enriched fractions	Antifungal (F. M.)	
		EtOH / Quercetin-3-galactoside-7-glucoside and quercetin-3-xyloside-7-glucoside	FLA	---	(Glennie and Jain, 1980)
	Sd	α- and β-amyrins, Friedelin, Epi-friedelinol, lupeol	TER	Antioxidant	(Jain *et al.*, 2008b)
		Stigmasterol, β-sitosterol	STR		
	Rt	Aq	---	Anticancer (Sarcoma 180 cell lines)	(Jain *et al.*, 1988)
			ALK, FLA, GLY, SAP, TAN, TER	---	(Fawzy *et al.*, 2013)
			---	Antibacterial (B.S., E.C., P.A.) Antifungal (A.N., C.A., P.C., and T.R.)	(Jain *et al.*, 2008c)
				Antioxidant	
			CHO, PHE, FLA	---	(Sindhu *et al.*, 2010)
		MeOH / Galegine /3-methyl-2-butenylguanidine	ALK	Antibacterial (S.A.), antifungal (C.A.)	(Jain *et al.*, 2007)
		MeOH	---	Antibacterial (E.C., and K.P.)	
				Antibacterial (B.S., E.C., P.A); antifungal (A.N., C.A., P.C., and T.R.)	(Jain *et al.*, 2008c)
		MeOH / Tetracosan 1-oyl 1-tetradecanoate / lignoceryl myristate	FA	---	(Sultana *et al.*, 2018)
		MeOH / β-amyrin stearate, β-amyrin palmitate and urs-	TER		

		12-en-3β-olyl oleate (β-amyrin oleate)			
		EtOH / β-cyanin fraction	FLA	Hypoglycaemic	
		EtOH	---	Antibacterial (S.F.) Antifungal (A.F.)	(Jain *et al.*, 1988)
			CHO, PHE, FLA, STR		(Sindhu *et al.*, 2010)
		PE/ α-β-amyrins and taraxasterol acetate	TER		
		PE/ Benzyl-2, 6- dimethoxy benzoate	O-methoxybenzoic acid derivatives		(Joshi, 1983)
		PE/ Bornyl ferulate	PHE		
		PE/ Linoleic acid, linolenic acid	FA		
		PE/ Phytol	TER		
		PE/ Stigmasterol	STR		
		n-butanol	CHO and PRT		(Sindhu *et al.*, 2010)
V. glabrata	Ap	Germacrene D and 6β-cinnamoyleudesman- 15-al	ED and GD	---	(Bohlmann *et al.*, 1980)
V. luetselhurgii	Rt	Germacrene D, Germacra-1(10),4-diene, 1β, 4β-dihydroxyeudesmane			
V. macrophylla	Ap	Germacrene D, caryophyllene epoxide and humulene	GD, STER		
	Rt	caryophyllene epoxide and borneolferulate	TER		
	Lf	Sesquiterpenes	EO	Antibacterial (K.P. and P.A.); antifungal (C.A.);anti-inflammatory (CIP, COIEE); antipyretic	(de Veras *et al.*, 2021)
V. montanoifolia	Wp	Aq	---	Antioxidant, hypoglycemic	(Vargas Vargas *et al.*, 2019)
V. negrensis	Ap	CHCl3 / 6β-cinnamoyloxy-1β-hydroxy-10α-metoxy-3-oxogermacra-4,5Z-ene	GD	Antibacterial (E.F., and S.A.)	(Mora *et al.*, 2013a)
V. pentanha		Germacrene D, 6β-cinnamoyloxy-germacra- 1 (I 0),4-diene	GD	---	(Bohlmann *et al.*, 1980)
V. peraffinis		MeOH	GU-ALK	Anti-hypertensive	(Compagnone *et al.*, 2008)

V. persicifolia		HX / 4β-cinnamoyloxy,1β,3α-dihydroxyeudesm-7,8-ene	ED	Anti-obesity	(Dalla Via *et al.*, 2014)
		HX / 4β-cinnamoyloxy,1β,3α-dihydroxyeudesm-7,8-ene		Anti-inflammatory	(Via *et al.*, 2015)
		HX / 4β-cinnamoyloxy,1β,3α-dihydroxyeudesm-7,8-ene		Anticancer (HCT-15, HeLa, HepG2, HL-60, K562, MCF-7, PC-3, SKUL, U251)	
	Lf	CHCl3	---	Hypoglycemic	(Perez G *et al.*, 1996)
V. seattonii	Ap	CHCl3 / elemanolide	STL	---	(Ortega *et al.*, 1985)
V. semitlecurrens	Rt	Borneol coumarate, ferulate	TER		(Bohlmann *et al.*, 1980)
	Ap	Bicyclogermacrene and humulene	STER		
V. sphaerocephala		PE and MeOH / 1-deoxyverocephol, 8,8′ -bis-8-deoxyverocephol, 8-deoxyverocephol, 8-O-methylverocephol, 9-dehydro-8-dehydroxyverocephol and verocephol	STL		(Arciniegas *et al.*, 2020)
		MeOH	PHE	Antioxidant, antibacterial (E.C., and S.A.)	(Rodríguez-Valdovinos *et al.*, 2021)
V. turbacensis		Me2CO / 6β-[cinnamoyloxy]- 3β,4α-dihydroxyeudesmane and 6β-[cinnamoyloxy]-eudesman-15-oic acid	ED	---	(Bruno-Colmenárez *et al.*, 2010)
	Lf& Bk	α-pinene, germacrene-D and δ-elemene	EO	Rhodesain inhibition	(Ogungbe *et al.*, 2010)
V. virginica	Lf and Fw	EtOH / 6-O-βE-p-coumaroyl-4α-hydroxyeudesmane 6-O-β-Z-p-coumaroyl-4α-hydroxyeudesmane 6-O-α-E-p-coumaroyl-1β-4α-dihydroxyeudesmane	ED	---	(Xu *et al.*, 2010)
	Lf and Fw	EtOH / Verbesinosides A-F	TER-SAP	---	(Xu *et al.*, 2009)
Cancer cells: HCT-15 (colorectal), HeLa (Cervix),HepG2 (Hepatic), HL-60, K562 (leukemia),MCF-7 (breast). PC-3 (prostate cancer), SKUL (lung), U251 (glioblastoma).					

Verbesina species' chemical and pharmacological profiling offers a comprehensive understanding of their potential for drug discovery and development. These plants exhibit a rich diversity of chemical constituents, including alkaloids, flavonoids, terpenoids, sesquiterpenes, and fatty acids. Pharmacological investigations have unveiled a wide range of therapeutic actions associated with *Verbesina*, such as anti-hypertensive effects, wound healing properties, diuretic activity, antioxidant effects, antibacterial and antifungal properties, anti-inflammatory effects, and even anti-obesity and anticancer activities. Researchers can identify bioactive compounds responsible for specific therapeutic effects by correlating the chemical composition with pharmacological actions, laying the groundwork for novel pharmaceutical development. The bioactive compounds isolated from *Verbesina* plants hold promise as lead molecules for developing new drugs, pending further research into their mechanisms of action, pharmacokinetics, and safety profiles. The urgency and importance of this further research cannot be overstated, as it is crucial to fully unlock the potential of *Verbesina* species for drug discovery and development.

4. Safety and Toxicity Considerations of *Verbesina* Medicinal Preparations

Safety and toxicity considerations are critical when utilizing *Verbesina* plants for medicinal purposes due to the diverse array of bioactive compounds they contain. Despite their long history of traditional use, caution is necessary, considering potential adverse effects. Factors influencing the safety profile include the species used, plant parts employed, preparation methods, and dosage. Limited scientific data on safety necessitates thorough preclinical and clinical studies to assess risks, establish safe dosage ranges, and ensure proper identification to avoid toxic species or misidentification. This underscores the importance of your work in further research. Pyrrolizidine alkaloids found in some *Verbesina* species pose particular concerns, emphasizing the need for careful evaluation and adherence to quality control standards. While *Verbesina* medicinal preparations hold therapeutic promise, carefully considering safety and toxicity is essential to maximize benefits and minimize risks in clinical practice (Lopez *et al.*, 1996, Al-Oqail *et al.*, 2016, Subramanian *et al.*, 2018, Tandon and Yadav, 2019, de Veras *et al.*, 2021).

5. Conservation Challenges and Sustainable Harvesting Practices

Conservation challenges and sustainable harvesting practices are crucial considerations when using *Verbesina* species, especially given the increasing demand for their medicinal and pharmacological properties. As with many medicinal plants, *Verbesina* species face threats such as habitat loss, overharvesting, climate change, and habitat degradation, which endanger their long-term survival. Sustainable harvesting practices must be implemented to ensure the continued availability of these valuable resources while safeguarding biodiversity and ecosystem integrity. This necessitates collaboration between local communities, conservation organizations, and governmental agencies to develop and implement effective conservation strategies. Sustainable harvesting involves practices such as selective harvesting, rotation of harvest sites, regulation of collection quotas, and cultivation initiatives to reduce pressure on wild populations. Furthermore, raising awareness among stakeholders about the importance of conservation and the value of preserving *Verbesina* species in their natural habitats is essential. Integrating conservation efforts with sustainable harvesting practices and community engagement can mitigate threats to *Verbesina* species and promote their long-term viability for future generations(Shukla, 2023).

6. Future Perspectives: Potential Applications and Research Directions

The vast potential applications and promising research directions across various fields for the genus *Verbesina* underscore the importance of collaboration. With its diverse bioactive compounds and pharmacological activities,

Verbesina species hold promise for numerous therapeutic applications in medicine and healthcare, potentially revolutionizing our approach to health and well-being. The potential impact of these species on human health and well-being cannot be overstated. Further exploration of their phytochemical composition, pharmacological effects, and mechanisms of action can unveil new therapeutic targets and drug candidates for treating various diseases and health conditions. Additionally, research focusing on the identification and characterization of novel compounds, as well as the development of standardized extracts and formulations, can facilitate the translation of traditional knowledge into evidence-based medical practices. The key to realizing the full potential of *Verbesina* species and addressing challenges related to their conservation, sustainable use, and commercialization lies in the collaborative efforts of researchers, healthcare professionals, conservationists, and indigenous communities. By fostering interdisciplinary research and innovation, the genus *Verbesina* can continue to inspire discoveries and applications with profound implications for human health and well-being.

7. Conclusion

The *Verbesina* genus presents diverse medicinal potential. Ethnomedicinal practices warrant scientific validation. Chemical profiling reveals bioactive compounds for drug discovery. Safety, conservation, and sustainable harvesting are vital. Collaborative research promises to harness its full potential for human well-being.

Abbreviations

A.F.: *Aspergillus flavus*,
A.N.: *Aspergillus niger*,
AgNPs: silver nanoparticles
ALK:alkaloids,
Ap: aerial parts,
Aq: aqueous,
ATQ: anthraquinones,
B.S.: *Bacillus subtilis*,
Bk: bark,
C.A.: *Candida albicans*,
C.F.: *Citrobacter freundii*,
CIP: Carrageenan-Induced Peritonitis,
COIEE: Croton Oil-Induced Ear Edema,
C.V.: *Chromobacteriumviolaceum*,
CHCl3: chloroform,
CHO: carbohydrates,
Dec: decoction,
E.A.: *Enterobacter aerogenes*,
E.C.: *Escherichia coli*,
E.F.: *Enterococcus faecalis*,
ED: eudesman Derivative,
EO: essential oil,
EtAc: Ethyl acetate,
EtOH: Ethanol,
Ex: extract,
F. M.: *Fusarium moniliforme*,
F.O.: *Fusarium oxysporum*,
FA: fatty acids,
FLA: flavonoids,
Fw: flowers,
GD: germacrane derivatives,
GLY-ALK: glycoalkaloids,
GLY: glycosides,
GU-ALK: guanidine alkaloid,
HA: hydroalcohol,
HX: Hexane,
Inf: infusion,

K.P.: *Klebsiella pneumoniae*,
L. I.: *Leishmania infantum*,
Lf: leaves,
Me2CO: acetone
MeOH: Methanol,
P.A.: *Pseudomonas aeruginosa*,
P.C.: *Penicillium chrysogenum*,
P.F.: *Plasmodium falciparum*,
p.o.: oral,
P.V.: *Proteus vulgaris*,
PE: Petroleum ether,
PHE: phenols,
PRT: proteins,
R.S.: *Rhizoctonia solani*,
Rt: roots,
S.A.: *Staphylococcus aureus*,
S.A.: *Streptococcus agalactiae*,
S.C.: *Staphylococcus coagulans*,
S.E.: *Staphylococcus epidermidis*,
S.F.: *Streptococcus faecalis*,
S.I.: *Staphylococcus intermedius*,
S.T.: *Salmonella typhi*,
SAP: saponins,
Sd: seeds
St: stem,
STER: sesquiterpene,

STL: sesquiterpene lactones,
STR: steroids / phytosterols,
STR-GLY: steroidal glycosides,
STR-SAP: steroidal saponins,
T.B.: *Trypanosoma brucei*,
T.C.: *Trypanosoma cruzi*,
T.R.: *Trichophyton rubrum*,
TAN: tannins,
TER: terpenes,
TER-SAP: terpenoidal saponins,
top.: topical,
V.C.: *Vibrio cholerae*,
Wp: whole plant

Data Availability: The data and materials supporting the conclusions of this article are included within the article.

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References

Abbas, F., El Sayed, Z., Dora, G., Ateya, A. & Samy, S. 2016. Phytochemical and biological studies of *Verbesina encelioides* (Cav.) Benth. and Hook. *Asian Journal of Phytomedicine and Clinical Research,* 4**,** 108-120.

Abdel-Sattar, E., Maes, L. & Salama, M. M. 2010. *In vitro* activities of plant extracts from Saudi Arabia against malaria, leishmaniasis, sleeping sickness and Chagas disease. *Phytotherapy Research,* 24**,** 1322-1328.

Agra, M. D. F., Freitas, P. F. D. & Barbosa-Filho, J. M. 2007. Synopsis of the plants known as medicinal and poisonous in Northeast of Brazil. *Revista Brasileira de Farmacognosia,* 17**,** 114-140.

Al-Oqail, M. M., Siddiqui, M. A., Al-Sheddi, E. S., Saquib, Q., Musarrat, J., Al-Khedhairy, A. A. & Farshori, N. N. 2016. *Verbesina encelioides*: cytotoxicity, cell cycle arrest, and oxidative DNA damage in human liver cancer (HepG2) cell line. *BMC complementary and alternative medicine,* 16**,** 126.

Albalawi, M. a. D., Bashir, N. a. O. & Tawfik, A. 2015. Anticancer and antifolate activities of extracts of six Saudi Arabian wild plants used in folk medicine. *Journal of Life Sciences,* 9**,** 334-340.

Albuquerque, M. R. J. R., Canuto, K. M., Pessoa, O. D. L., Nunes, E. P., Nascimento, R. F. & Silveira, E. R. 2006. Essential oil composition of *Verbesina diversifolia* DC. *Flavour and Fragrance Journal,* 21**,** 634-636.

Almehdar, H., Abdallah, H. M., Osman, A.-M. M. & Abdel-Sattar, E. A. 2012. *In vitro* cytotoxic screening of selected Saudi medicinal plants. *Journal of Natural Medicines,* 66**,** 406-412.

Alonso-Castro, A. J., Villarreal, M. L., Salazar-Olivo, L. A., Gomez-Sanchez, M., Dominguez, F. & Garcia-Carranca, A. 2011. Mexican medicinal plants used for cancer treatment: Pharmacological, phytochemical and ethnobotanical studies. *Journal of Ethnopharmacology,* 133**,** 945-972.

Arciniegas, A., Pérez-Castorena, A.-L., Villaseñor, J. L. & Romo De Vivar, A. 2020. Cadinenes and other metabolites from *Verbesina sphaerocephala* A. Gray. *Biochemical Systematics and Ecology,* 93**,** 104183.

Ayub, M., Shah, G. M., Irfan, M., Ullah, F. & Ullah, A. 2023. Ethnomedicinal study of the flora of Sellay Pattay valley, District Malakand, Khyber Pakhtunkhwa, Pakistan. *Ethnobotany Research and Applications,* 26**,** 1-17.

Bohlmann, F., Grenz, M., Gupta, R. K., Dhar, A. K., Ahmed, M., King, R. M. & Robinson, H. 1980. Eudesmane derivatives from *Verbesina* species. *Phytochemistry,* 19**,** 2391-2397.

Bruno-Colmenárez, J., Amaro-Luis, J. M., Ramírez, I., Delgado-Méndez, P. & Díaz De Delgado, G. 2010. Absolute configuration of two Eudesmane derivatives from *Verbesina turbacensis* H.B.K. *Journal of Chemical Crystallography,* 40**,** 110-115.

Bye, R. & Linares, E. 1986. Ethnobotanical notes from the valley of San Luis, Colorado. *Journal of Ethnobiology,* 6**,** 289-306.

Campbell, T. N. 1951. Medicinal plants used by Choctaw, Chickasaw, and Creek Indians in the early nineteenth century. *Journal of the Washington Academy of Sciences,* 41**,** 285-290.

Canales, M., Hernández, T., Caballero, J., Vivar, A. R. D., Avila, G., Duran, A. & Lira, R. 2005.

Informant consensus factor and antibacterial activity of the medicinal plants used by the people of San Rafael Coxcatlán, Puebla, México. *Journal of Ethnopharmacology,* 97**,** 429-439.

Carmignani, M., Volpe, A. R., Botta, B., Espinal, R., De Bonnevaux, S. C., De Luca, C., Botta, M., Corelli, F., Tafi, A., Sacco, R. & Delle Monache, G. 2001. Novel hypotensive agents from *Verbesina caracasana*. 8. Synthesis and pharmacology of (3,4-Dimethoxycinnamoyl)-N-agmatine and synthetic analogues1. *Journal of Medicinal Chemistry,* 44**,** 2950-2958.

Chauhan, A. & Rijhwani, S. 2015. Isolation and purification of bioactive compounds from *Verbesina encelioides*: an underexploited medicinal plant. *IIS University Journal of Science and Technology,* 4**,** 33-35.

Cilia-López, V. G., Cariño-Cortés, R. & Zurita-Salinas, L. R. 2021. Ethnopharmacology of the Asteraceae family in Mexico: La Etnofarmacología de la Familia Asteraceae en México. *Botanical Sciences,* 99**,** 455-486.

Compagnone, R. S., Bermudez, J., Ibáñez, G., Diaz, B., Garrido, M. R., Israel, A. & Suarez, A. I. 2008. New guanidine alkaloids from the leaves of *Verbesina peraffinis*. *Natural Product Communications,* 3**,** 511-514.

Dalla Via, L., N Garcia-Argaez, A., Braga, A., Martinez-Vazquez, M., Grancara, S., Martinis, P., Agostinelli, E. & Toninello, A. 2014. An eudesman derivative from *Verbesina persicifolia* DC as a natural mild uncoupler in liver mitochondria. A new potential anti-obesity agent? *Current Pharmaceutical Design,* 20**,** 253-261.

De Veras, B. O., De Oliveira, J. R. S., De Menezes Lima, V. L., Do Amaral Ferraz Navarro, D. M., De Oliveira Farias De Aguiar, J. C. R., De Medeiros Moura, G. M., Da Silva, J. W., De Assis, C. R. D., Gorlach-Lira, K., De Assis, P. a. C., De Souza Barbosa, J. I., De Melo, M. R. C. S., De Oliveira, M. B. M., Da Silva, M. V. & De Souza Lopes, A. C. 2021. The essential oil of the leaves of *Verbesina macrophylla* (Cass.) S.F.Blake has antimicrobial, anti-inflammatory and antipyretic activities and is toxicologically safe. *Journal of Ethnopharmacology,* 265**,** 113248.

Deiró, E., Vale, V., Boness, H. & Marques, E. 2023. Biological and phytochemical study of the leaves of *Verbesina macrophylla* (Cass.) SF Blake (Asteraceae): Estudo biológico e fitoquímico das folhas de *Verbesina macrophylla* (Cass.) SFBlake (Asteraceae). *Concilium,* 23**,** 712-735.

Delle Monache, G., Botta, B., Delle Monache, F., Espinal, R., De Bonnevaux, S. C., De Luca, C., Botta, M., Corelli, F., Dei, D., Gacs-Baitz, E. & Carmignani, M. 1996. Caracasandiamide, a truxinic hypotensive agent from *Verbesina caracasana*. *Bioorganic & Medicinal Chemistry Letters,* 6**,** 233-238.

Delle Monache, G., Botta, B., Monache, F. D., Espinal, R., De Bonnevaux, S. C., De Luca, C., Botta, M., Corelli, F. & Carmignani, M. 1993. Novel hypotensive agents from *Verbesina caracasana*. 2. Synthesis and pharmacology of caracasanamide. *Journal of Medicinal Chemistry,* 36**,** 2956-2963.

Eichholzer, J. V., Lewis, I. A., Macleod, J. K., Oelrichs, P. B. & Vallely, P. J. 1982. Galegine and a new dihydroxyalkylacetamide from *Verbesina enceloiodes*. *Phytochemistry,* 21**,** 97-99.

Farshori, N. N. 2021. *Verbesina encelioides* - induced cytotoxicity and mitochondria-mediated apoptosis in human colon cancer cells through ROS generation. *Biologia,* 76**,** 2711-2720.

García-Bores, A. M., Álvarez-Santos, N., López-Villafranco, M. E., Jácquez-Ríos, M. P., Aguilar-Rodríguez, S., Grego-Valencia, D., Espinosa-González, A. M., Estrella-Parra, E. A., Hernández-Delgado, C. T. & Serrano-Parrales, R. 2020. *Verbesina crocata*: A pharmacognostic study for the treatment of wound healing. *Saudi Journal of Biological Sciences,* 27**,** 3113-3124.

Gouda, Y. G., Abdallah, Q., Elbadawy, M. F., Basha, A. A., Alorabi, A. K., Altowerqe, A. S. & Mohamed, K. M. 2014. Cytotoxic and antimicrobial activities of some compositae plants growing in Taif area, Saudi Arabia. *International Journal of Pharmaceutical Science Invention,* 3**,** 43-48.

Heyerdahl-Viau, I., López-Naranjo, F., Córdova-Moreno, R. & Urbina-Pastrana, A. 2023. A brief review of *Verbesina crocata* (Cav.) Less., a scantly studied medicinal plant. *Research Journal of Pharmacognosy,* 10**,** 51-56.

Jain, S., Jain, R., Singh, R. & Menghani, E. 2008. *Verbesina encelioides*: Perspective and potentials of a noxious weed. *Indian Journal of Traditional Knowledge,* 7**,** 511-513.

Jain, S. C., Purohit, M. & Sharma, R. 1988. Pharmacological evaluation of *Verbesina encelioides*. *Phytotherapy Research,* 2**,** 146-148.

Jerezano Alberto, V., Ríos Saúl, A., Tepancal-Gomez, E., Salas-Mendosa, E. & Villanueva, L. 2016. Some traditional medicinal plants of North region from Puebla, Mexico: Uses and potential pharmacological activity of *Rumex* spp. *Natural Products Chemistry and Research,* 4**,** 223.

Josabad Alonso-Castro, A., Jose Maldonado-Miranda, J., Zarate-Martinez, A., Jacobo-Salcedo, M. D. R., Fernández-Galicia, C., Alejandro Figueroa-Zuñiga, L., Abel Rios-Reyes, N., Angel De León-Rubio, M., Andrés Medellín-Castillo, N., Reyes-Munguia, A., Méndez-Martínez, R. & Carranza-Alvarez, C. 2012. Medicinal plants used in the Huasteca Potosina, México. *Journal of Ethnopharmacology,* 143**,** 292-298.

Joshi, K. 1983. Chemical constituents of *Verbesina encelioides* and *Holmskioldia sanguinea*. *Journal of the Indian Chemical Society,* 60**,** 905-906.

Lopez, T., Campero, C., Chayer, R., Cosentino, B. & Caracino, M. 1996. Experimental toxicity of *Verbesina encelioides* in sheep and isolation of galegine. *Veterinary and human toxicology,* 38**,** 417-419.

Martínez-Hernández, M., Torres-Pelayo, V. & Castillo-Rocha, D. 2022. Traditional medicine in the health systems of communities: A first exploring in Veracruz State, Mexico. *International Journal of Environment, Agriculture and Biotechnology,* 7**,** 52-69.

Merriam-Webster. 1828. *Verbesina. Merriam-Webster.com Dictionary, https://www.merriam-webster.com/dictionary/verbesina*[Online]. [Accessed 2nd January 2024].

Milliken, W., Walker, B. E., Howes, M.-J. R., Forest, F. & Nic Lughadha, E. 2021. Plants used traditionally as antimalarials in Latin America: Mining the tree of life for potential new medicines. *Journal of Ethnopharmacology,* 279**,** 114221.

Monache, G. D., Volpe, A. R., Monache, F. D., Vitali, A., Botta, B., Espinal, R., De Bonnevaux, S. C., Luca, C. D., Botta, M., Corelli, F. & Carmignani, M. 1999. Further hypotensive metabolites from *Verbesina caracasana*. *Bioorganic & Medicinal Chemistry Letters,* 9**,** 3249-3254.

Mora, F., Alpan, L., De Tommasi, N., Mccracken, V. & Nieto, M. 2013a. New antibacterial germacrene from *Verbesina negrensis*. *Planta Medica,* 79**,** 707-710.

Mora, F. D., Alpan, L., Mccracken, V. J. & Nieto, M. 2013b. Chemical and biological aspects of the genus *Verbesina*. *The Natural Products Journal,* 3**,** 140-150.

Moreira, R. D. C. T., Costa, L. C. D. B., Costa, R. C. S. & Rocha, E. A. 2002. Abordagem etnobotânica acerca do uso de plantas medicinais na Vila Cachoeira, Ilhéus, Bahia, Brasil. *Acta Farmacêutica Bonaerense,* 21**,** 205-211.

Ogungbe, I. V., Crouch, R. A., Haber, W. A. & Setzer, W. N. 2010. Phytochemical investigation of *Verbesina turbacensis* Kunth: Trypanosome cysteine protease inhibition by (–)-bornyl esters. *Natural Product Communications,* 5**,** 1161 - 1166.

Ortega, A., Maldonado, E., Fronczek, F. R., Delord, T. J. & Chiari, G. 1985. Elemanolides from *Verbesina seattonii*. *Phytochemistry,* 24**,** 1755-1760.

Panero, J. L. & Strother, J. L. 2021. Chromosome Numbers in *Verbesina* (Asteraceae, Heliantheae, Verbesininae). *Lundellia,* 24**,** 1-10.

Parrotta, J. 2001. *Healing plants of Peninsular India. 155-156,* U.S.A., CABI Publishing.

Pérez G, R. M., Ocegueda Z, A., Muñoz L, J. L., Avila A, J. G. & Morrow, W. W. 1984. A study of the hypoglucemic effect of some Mexican plants. *Journal of Ethnopharmacology,* 12**,** 253-262.

Perez G, R. M., Perez G, S., Zavala, M. A. & Perez G, S. C. 1996. Effect of *Agarista mexicana* and *Verbesina persicifolia* on blood glucose level of normoglycaemic and Alloxan-diabetic mice and rats. *Phytotherapy Research,* 10**,** 351-353.

Rodríguez-Valdovinos, K. Y., Salgado-Garciglia, R., Vázquez-Sánchez, M., Álvarez-Bernal, D., Oregel-Zamudio, E., Ceja-Torres, L. F. & Medina-Medrano, J. R. 2021. Quantitative analysis of Rutin by HPTLC and in vitro antioxidant and antibacterial activities of phenolic-rich extracts from *Verbesina sphaerocephala*. *Plants* [Online], 10.

Salazar-Gómez, A. & Alonso-Castro, A. J. 2022. Medicinal Plants from Latin America with Wound Healing Activity: Ethnomedicine, Phytochemistry, Preclinical and Clinical Studies—A Review. *Pharmaceuticals,* 15**,** 1095.

Salazar-Gómez, A., Pablo-Pérez, S. S., Estévez-Carmona, M. M. & Meléndez-Camargo, M. E. 2018. Diuretic activity of aqueous extract and smoothie preparation of *Verbesina crocata* in rat. *Bangladesh Journal of Pharmacology,* 13**,** 236-240.

Shukla, S. K. 2023. Conservation of medicinal plants: challenges and opportunities. *Journal of Medicinal Botany,* 7**,** 5-10.

Singh, L. & Dahiya, P. 2017. Evaluation of antimicrobial, phytochemicals, total phenolic and flavonoid contents of *Verbesina encelioides* - A lesser known herb of family Asteraceae. *International Journal of Latest Research in Science and Technology,* 6**,** 27-30.

Solanki, V., Begam, T. & Hussain, S. 2021. Phytochemical studies on some selected species of Asteraceae family of Rajasthan, India. *Plant Archives,* 21**,** 62-65.

Strother, J. & Flora of North America Editorial Committee 2006. *Verbesina*. *Flora of North America: Volume 21: Magnoliophyta: Asteridae, Part 8: Asteraceae, Part 3.pp. 106–111.* New York, USA: Oxford University Press

Subramanian, K., Sankaramourthy, D. & Gunasekaran, M. 2018. Toxicity studies related to medicinal plants. *Natural Products and Drug Discovery.* Elsevier.

Tandon, N. & Yadav, S. S. 2019. Safety and Toxicity of Medicinal Plants: Concerns and Overview. *Natural Medicines.* CRC Press.

Treben, M. 2007. *Health Through God's Pharmacy: Advice and Proven Cures with Medicinal Herbs*, Ennsthaler.

Trillo, C., Arias Toledo, B., Galetto, L. & Colantonio, S. 2010. Persistence of the use of medicinal plants in rural communities of the Western Arid Chaco [Córdoba, Argentina]. *The Open Complementary Medicine Journal,* 2**,** 80-89.

Vargas Vargas, M., Vázquez-Hernández, A., Torner, L., Punthakee, Z., Goldenberg, R., Katz, P., Nowotny, K., Jung, T., Höhn, A. & Deber, W. 2019. Hypoglycemic and antioxidant effects of oral treatment of *Verbesina montanoifolia* extract in diabetic rats. *Planta Medica,* 85**,** 1532.

Vásquez, J., Alarcón, J. C., Jiménez, S. L., Jaramillo, G. I., Gómez-Betancur, I. C., Rey-Suárez, J. P., Jaramillo, K. M., Muñoz, D. C., Marín, D. M. & Romero, J. O. 2015. Main plants used in traditional medicine for the treatment of snake bites n the regions of the department of Antioquia, Colombia. *Journal of Ethnopharmacology,* 170**,** 158-166.

Velasco-Ramírez, A. P., Velasco-Ramírez, S. F. & Velasco-Ramírez, A. 2019. Uso en medicina tradicional de *Verbesina sphaerocephala* A. Gray (Asteraceae) en la comunidad de San Martin de las Flores, Jalisco, México: Use in traditional medicine of *Verbesina sphaerocephala* A. Gray (Asteraceae) in the community of San Martin de las Flores, Jalisco, Mexico. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas,* 18**,** 144-154.

Via, L., Mejía, M., García-Argáez, A., Braga, A., Toninello, A. & Martínez-Vázquez, M. 2015. Anti-inflammatory and antiproliferative evaluation of 4b-cinnamoyloxy, 1b, 3a-dihydroxyeudesm-7, 8-ene from *Verbesina persicifolia* and derivatives. *Bioorganic & Medicinal Chemistry,* 23**,** 5816-5828.

Waizel-Bucay, J. & Waizel-Haiat, S. 2009. Antitussive plants used in Mexican traditional medicine. *Pharmacognosy Reviews,* 3**,** 29-43.

Weimann, C. & Heinrich, M. 1997. Indigenous medicinal plants in Mexico: the example of the Nahua (Sierra de Zongolica). *Botanica Acta,* 110**,** 62-72.

Wfo. 2024. *Verbesina L.*Published on the Internet; *https://wfoplantlist.org/taxon/wfo-4000040144-2023-12?page=1* [Online]. [Accessed 1st January 2024].

Xu, W.-H., Jacob, M. R., Agarwal, A. K., Clark, A. M., Liang, Z.-S. & Li, X.-C. 2009. Verbesinosides A−F, 15,27-cyclooleanane saponins from the American native plant *Verbesina virginica*. *Journal of Natural Products,* 72**,** 1022-1027.

Xu, W. H., Liang, Q., Liang, Z. S. & Li, X. C. 2010. Two new eudesmane derivatives from *Verbesina virginica*. *Chinese Chemical Letters,* 21**,** 693-695.