

ETHNOPHARMACOLOGY, PHYTOCHEMISTRY, AND PHARMACOLOGICAL EVALUATION OF KHAJURASAVA: AN AYURVEDIC FERMENTED FORMULATION

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ABSTRACT

Rajayakshma, described in Ayurveda as a condition arising from *Dhatukshaya* and *Dhatwagninasana*, closely parallels tuberculosis (TB) in modern medicine. Progressive depletion of tissues—*rasa*, *rakta*, *mamsa*, *meda*, *sukra*, and ultimately *ojas*—leads to profound immune compromise (*Ojokshaya*), forming the core of its pathogenesis. Although Anti-Tubercular Treatment (ATT) remains the mainstay of modern TB therapy, its long-term use is frequently associated with complications such as hepatotoxicity, oxidative stress, inflammation, and reduced patient compliance. These limitations highlight the need for safe, supportive interventions that can enhance therapeutic outcomes. Sandhana Kalpana, an Ayurvedic fermentation process, offers formulations with improved bioavailability and inherent antioxidant, immunomodulatory,

and hepatoprotective properties. Khajurasava—prepared from *Phoenix dactylifera*, *Juniperus communis*, and *Woodfordia fruticosa*—is traditionally indicated for Rajayakshma. This review compiles classical references and modern scientific evidence to evaluate the formulation's potential relevance in TB management. Phytochemical analysis shows that the ingredients are rich in phenolic acids, flavonoids, proanthocyanidins, volatile oils, and tannins. Pharmacological studies demonstrate potent antioxidant, anti-inflammatory, immunomodulatory, hepatoprotective, and lung-protective activities, all of which address key

pathological components of TB and its treatment-related toxicities. Collectively, the evidence suggests that Khajurasava may serve as an effective supportive formulation alongside conventional ATT by reducing drug-induced side effects, enhancing immune function, and improving overall treatment tolerance. Future preclinical and clinical studies are warranted to validate its integrative therapeutic role and establish its safety and efficacy in TB management.

KEYWORDS: *Rajyakshma*, *Kharjura*, Phytoconstituents, Fermented Formulation.

INTRODUCTION

Rajyakshma is primarily attributable to *Dhatukshaya* (tissue emaciation or loss). This process universally initiates the process of pathogenesis in *Rajyakshma* patients. In addition, there is inevitable metabolic dysfunction (*Dhatwagninasana*), in which *rasa* (tissue fluid), *rakta* (blood), *mamsa* (muscle), *meda* (adipose tissue), and *sukra* (generative tissue) are lost. This leads to ultimate deterioration of immunity or *ojokshaya*. As per Ayurvedic concepts, an unusual metabolic change occurs leading to loss of various *dhatus* (tissue) such as *Ojokshaya*, *sukra*, *meda dhatus* to *rasa dhatu* preceding each other, which is known as *Pratilomakshaya*.

The term *Rajyakshma* is conceptually correlated with tuberculosis (TB) in modern medicine. TB is a chronic infectious disease caused by *Mycobacterium tuberculosis*. While it primarily affects the lungs, it can also impact other organs such as the bones, brain, kidneys, liver, and lymph nodes. Its management in modern medicine primarily relies on Anti-Tubercular Treatment (ATT). However, prolonged use of ATT is often associated with complications such as hepatotoxicity, oxidative stress, immunosuppression, and poor treatment compliance, all of which pose serious challenges to long-term therapeutic success.

These adverse effects highlight the urgent need for supportive therapies that can mitigate these complications and improve overall treatment outcomes. This underscores the potential relevance of Ayurvedic supportive interventions that can complement conventional therapy by reducing side effects and enhancing efficacy. *Sandhana Kalpana*, the Ayurvedic science of fermentation, holds a distinct position among various pharmaceutical processes due to its dual benefits—medicinal efficacy and nutritional value. This process involves the fermentation of decoctions or cold infusions wherein a quantity of sweetening agents, such as jaggery or honey, is added alongside inoculum-bearing herbs. The mixture is then

allowed to ferment anaerobically over a prolonged period, leading to the generation of self-derived alcohol which acts both as a preservative and an extractor of active constituents—water- and alcohol-soluble—thus enhancing the therapeutic potential of the formulation.

Classical Ayurvedic texts describe a wide range of fermented formulations under *Sandhana Kalpana*, including *Sura*, *Sidhu*, *Varuni*, *Asava*, *Arishta*, *Sukta*, *Kanjika*, and *Sandaki*. Among these, *Asava* and *Arishta* are the most widely used due to their pleasant organoleptic properties, long shelf life, and enhanced bioavailability of phytoconstituents.

Khajurasava, cited in classical Ayurvedic texts such as *Rasa Tantra Sara* and *Siddha Prayoga Sangraha*, comprising *Phoenix dactylifera*, *Juniperus communis*, and *Woodfordia fruticosa*. It is classically indicated in the management of *Rajayakshma*. Considering this traditional indication, it is likely that *Khajurasava* may offer therapeutic benefits not only in the management of tuberculosis but also in mitigating the side effects associated with anti-tubercular treatment (ATT).

Therefore, the present review aims to compile scattered data, evaluate the pharmacological properties of its individual ingredients, and explore its potential as an integrative therapeutic agent in tuberculosis management. This evidence-based exploration may serve as a foundation for future preclinical and clinical research within modern healthcare systems.

METHODOLOGY

All the information summarized in this review article was derived from classical Ayurvedic texts (*Vaidhya Chintamani*, *Rasa Tantra Sara Evam Sidhaprayoga Sangraha*, *Yogaratanakara*, *Gadanigraha*, *Brihta Nighantu Ratnakara*) and original research articles from PUBMED, Google Scholar, Science Direct, Web of Science, and Scopus. The keywords used for searching relevant research articles included: "*Ayurveda*," "*Khajurasava*," "*Khajura*," "*Phoenix dactylifera*," "*Dhataki*," "*Woodfordia fruticosa*," "*Hapusa*," "*Juniperus communis*," "geographical distribution," "ethnomedicinal uses," "phytochemistry," and "pharmacological activity." This search was conducted till 2024, focusing only on literature published in English.

Composition of *Khajurasava*

Khajurasava is prepared using the fruit of *Phoenix dactylifera* Linn. (*Kharjura*, family *Arecaceae*) in a proportion of 10 parts, along with the berries of *Juniperus communis* Linn.

(Hapusha, family Pinaceae) and the flowers of *Woodfordia fruticosa* Kurz. (Dhataki, family Lythraceae) in 1 part each, and 64 parts of water (Fig. 1).

Geographical Distribution and Ethno- medicinal Uses

All the ingredients of *Khajurasava* are distributed across various parts of the world, including the Indian subcontinent. These plants have traditionally been used for a wide range of therapeutic purposes such as nutritive, carminative, digestive, anti-inflammatory, rejuvenative, and disease-specific applications including diabetes, liver disorders, respiratory ailments, skin conditions, and gynecological complaints. The geographical distribution and ethnomedicinal uses of the plant ingredients of *Khajurasava* are detailed in Table 1.

Table 1: Geographical distribution and ethno-medicinal use of plants ingredients of Khajurasava.

S. No	Ingredients	Geographical Distribution	Ethno -Medicinal Uses
1.	Khajura	Mesopotamia (Iraq). ^[2] Babylon, Assyria. ^[3,4] Arabian Peninsula, Middle East, North Africa, Pakistan, India, Australia, Mexico, South America, United States, Southern Africa	Nutritive, Fatigue, Diabetes, Hypertension, Chest complaints, Cough, Asthma, Gastroenteritis. ^[5,6,7] Liver diseases, Conditions related to pregnancy (before and after delivery). ^[8] Infertility in women. ^[9] Fever, Inflammation, Loss of consciousness, Memory disturbances, Nervous disorders, Paralysis. ^[10]
3.	Hapusa	Manimahesh (Chamba), Kullu, Churdhar (Sirmour), Chhota and Bara Bhangal (Kangra), Kinnaur, Pattan Valley (Lahaul-Spiti), Europe, South-western Asia, North America. ^[1]	Carminative, urinary antiseptic, diuretic, emmenagogue, sudorific, digestive, and anti-inflammatory. ^[12,13]
		Southern Asia:	
		Bhutan, China (Yunnan, Guangdong, Guangxi),	Sunstroke, Cold ¹⁶ . Wound healing. ^[17]
		Japan, India, Myanmar	Leucoderma (Kondha tribe of
		(Burma), Nepal, Vietnam,	Orissa). ^[18] Ulcers (Vrana). ^[19] Rheumaic
2.	Dhataki	Malaysia, Pakistan, Sri Lanka),	pain (southern part). ^[20] Toothache, Blood infection, Leprosy, Dysentery,
		Gulf Nations:	Pediatric diarrhoea. Fever, urinary
		(Saudi Arabia (Southwest –	disorder, swelling, menstrual
		Asir region), Oman (Dhofar	problems (Nepal). ^[21]
		region), Other Regions:	
		(Java, Sumatra,	
		Madagascar,	
		Tanzania, Comores). ^[14,15]	

Phytochemistry

Phytochemical investigations into the individual plant ingredients of *Khajurasava* have been conducted extensively over the decades. A wide range of phytomolecules has been identified from the ingredients parts used in the formulation, including Phenolic Acids, flavonoid glycosides and esters, Flavan-3-ols, Proanthocyanidins, Anthocyanins, Carotenoids, Polysaccharides, Flavonoids, Volatile oils, Tannin, Phytosterol, Glycoside, Phenolic, Steroid, Flavonoid, Fatty alcohol. Their detailed classification, along with methods of isolation and characterization, are summarized in Table, while chemical structures are illustrated in Figures.

In *P. dactylifera*, the major phytoconstituents include gallic acid, caffeic acid, ferulic acid, quercetin, catechin, β -carotene, and procyanidins, along with pectin and other polysaccharides. These compounds have been identified using advanced techniques such as HPLC, LC-MS/MS, UV-Vis spectroscopy, FTIR, and NMR.

J. communis is rich in compounds like α -pinene, sabinene, myrcene, limonene, apigenin, rutin, quercitrin, and amentoflavone. The volatile oils were extracted using the Clevenger apparatus through hydrodistillation and characterized primarily using GC-MS.

W. fruticosa contains significant phytoconstituents such as oenotherin B, woodfordin derivatives, ellagic acid, kaempferol, quercetin, β -sitosterol, astragalin, and chrysophanol glucoside, identified through HPLC, UV-Vis, NMR, IR, and MS.

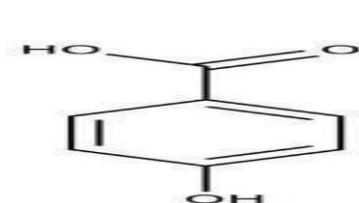
Table 2: List of phytoconstituents isolated from the specific plant parts used in *Khajurasava*.

Phoenix dactylifera	Classification	Isolated compound name	Method of characterization	Reference
	Phenolic Acids	Benzoic acids and derivatives: p-Hydroxybenzoic acid, Protocatechuic acid, Gallic acid, Syringic acid, Sinapic acid, Vanillic acid	HPLC, LC-MS/MS, UV-VIS spectroscopy	[22,23,24,25] [26,27,28,29,30]
		Cinnamic acid and derivatives: Caffeic acid, p-Coumaric acid, Ferulic acid, Hydrocaffeic acid, Dactyliferic acid, 3/4/5-Caffeoylshikimic acid, Dicafeoylsinapoyl hexoside	HPLC, LC-MS/MS	
	Flavonoid	Rutin, luteolin, apigenin, quercetin	LC-MS/MS, NMR,	[22,23,24,25]

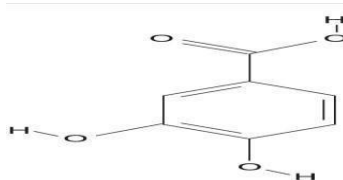
	glycosides and esters	(and its derivatives: hexoside sulfate, acetyl-hexoside, rhamnosyl-hexoside), isorhamnetin derivatives (isorhamnetin hexoside, acetyl-hexoside, 3-O-rutinoside), chrysoeriol derivatives (rhamnosyl-hexoside, hexoside sulfate, hexoside), and isoquercitrin	UV-Vis, HPTLC	[26,27,28,29,30, 31,32]
	Flavan -3-ols	Catechin (+), Epicatechin (-)	HPLC, LC-MS	[22,23,24,25],[26,27,28,29,30]
	Proanthocyanidins	Procyanidin B1, B2, Trimer, Tetramer, Pentamer	HPLC, MS	[22,23,24,25] [26,27,28,29,30]
	Anthocyanins	Cyanidin	UV-VIS, HPLC	[22,23,24,25] [26,27,28,29,30]
	Carotenoids	β -Carotene, Lutein, Lycopene, Violaxanthin, Flavoxanthin, Neoxanthin, Leukoxanthin	Spectrophotometr, HPLC	[33]
	Polysaccharides	Pectin (6.7% unripe, 2.3% ripe)	Gravimetric, FTIR	[34]
<i>Juniperus communis</i>	Classification	Isolated compound name	Method of characterization	Reference
	Flavonoids	Apigenin, rutin, luteolin, quer- cetin-3-O-arabinosyl-glucoside, quercetin-3-o-rhamnoside (Quercitrin), scutellarein, nepetin, amentoflavone, bilobetin	HPLC,LC-MS/M S,NMR	[35,36,37,38,39,40]
	Volatile oils	Berry oil : α -Pinene (51.4%), Sabinene (5.8%), β -Pinene (5.0%), Myrcene (8.3%), Limonene (5.1%)	GC-MS	[41,42]
		d- α -Pinene, Camphene, Hydrocarbon-junene, Dihydrojunene, Cadinene, Juniper, Camphor	GC-MS	[42]
	Other constituents	Pectins, Glycolic acid, Malic acid, Formic acid, Acetic acid, Cyclohexitol, Proteins, Fermentable sugars, Wax, Gum, Ascorbic acid	UV-Vis, FTIR, TLC	[42]
<i>Woodfordia fruticosa</i>	Classification	Isolated compound name	Method of characterization	Reference
	Tannin	1,2,3,4,6-penta-O-galloyl- β -D-glucose,	HPLC, NMR, MS, UV-Vis spectroscopy	[43,44,45,46]
		1,2,3,6-tetra-O-galloyl- β -D-glucose, Gemin D, Heterophylliin A, Oenothien B, Oenothien C, Woodfordin A-I, Woodfructosin, Tellimagrandin,		
		Isoschimawalin A		
	Phytosterol	β -Sitosterol	GC-MS, IR spectroscopy, NMR	[47]
	Glycoside	Astragalin, Kaempferol-3-glucoside,	HPLC, LC-MS,	[47,48]

	Chrysophanol-8-O- β -D-glucopyranoside, Juglalin, Kaempferol	NMR	
	3-O-arabinoside, Kaempferol		
	3-O-(6''-galloyl)- β -D-Glucopyranoside		
Phenolic	Ellagic acid, Gallic acid	UV-Vis, HPLC, FTIR	[49,50,51]
Steroid	Hecogenin	GC-MS, IR, NMR	[50]
Flavonoid	Kaempferol, Quercetin	HPLC, UV-Vis, LC-MS	[49]
Fatty alcohol	Octacosanol	GC-MS, NMR, IR	[47]

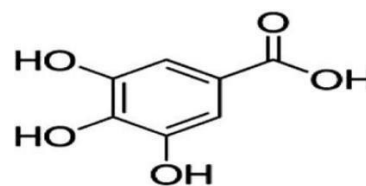
Benzoic acids and derivatives



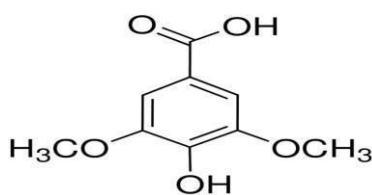
P-hydroxybenzoic acid



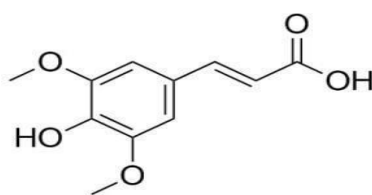
Protocatechuic acid



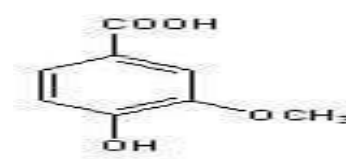
Gallic acid



Syringic acid

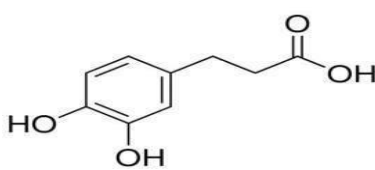


Sinapic acid

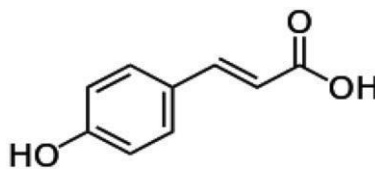


Vanillic acid

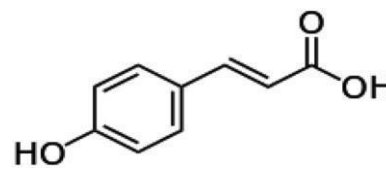
Cinnamic acid and derivatives



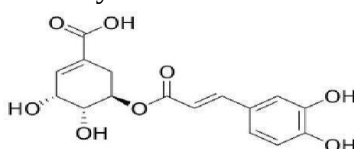
Hydrocaffeic acid



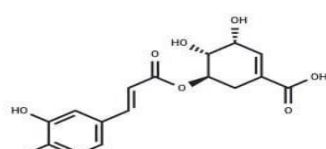
Coumaric acid



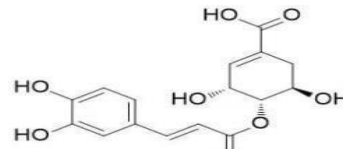
Ferulic acid



Dactyferic acid

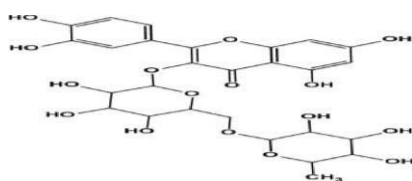


5 caffeoylshikimic acid

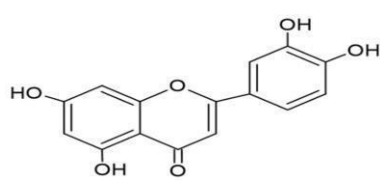


4 caffeoylshikimic acid

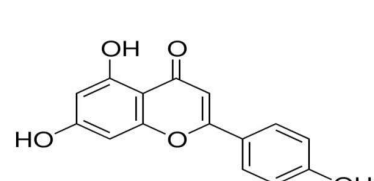
Flavonoid



Rutin



Luteolin



Apigenin

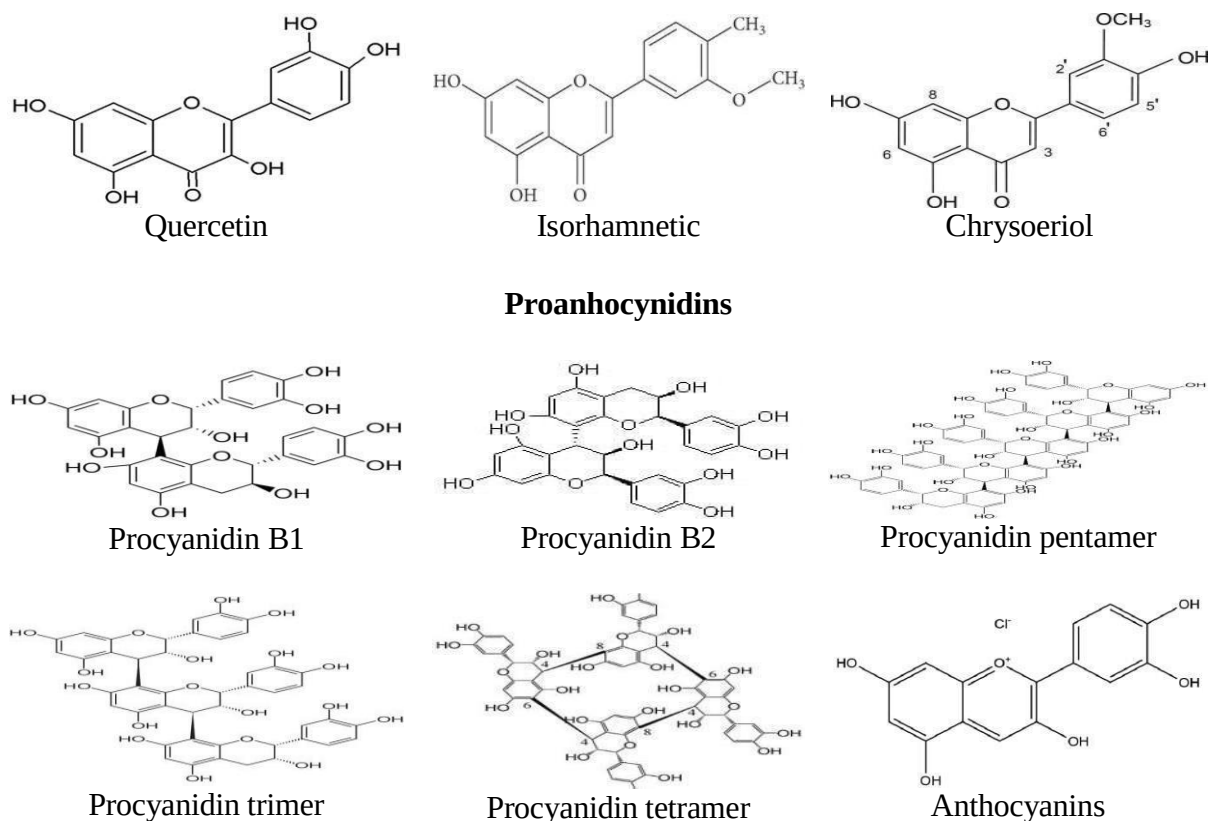


Fig 1. Chemical structures of key bioactive phytochemicals from fruit of *P. dactylifera*.

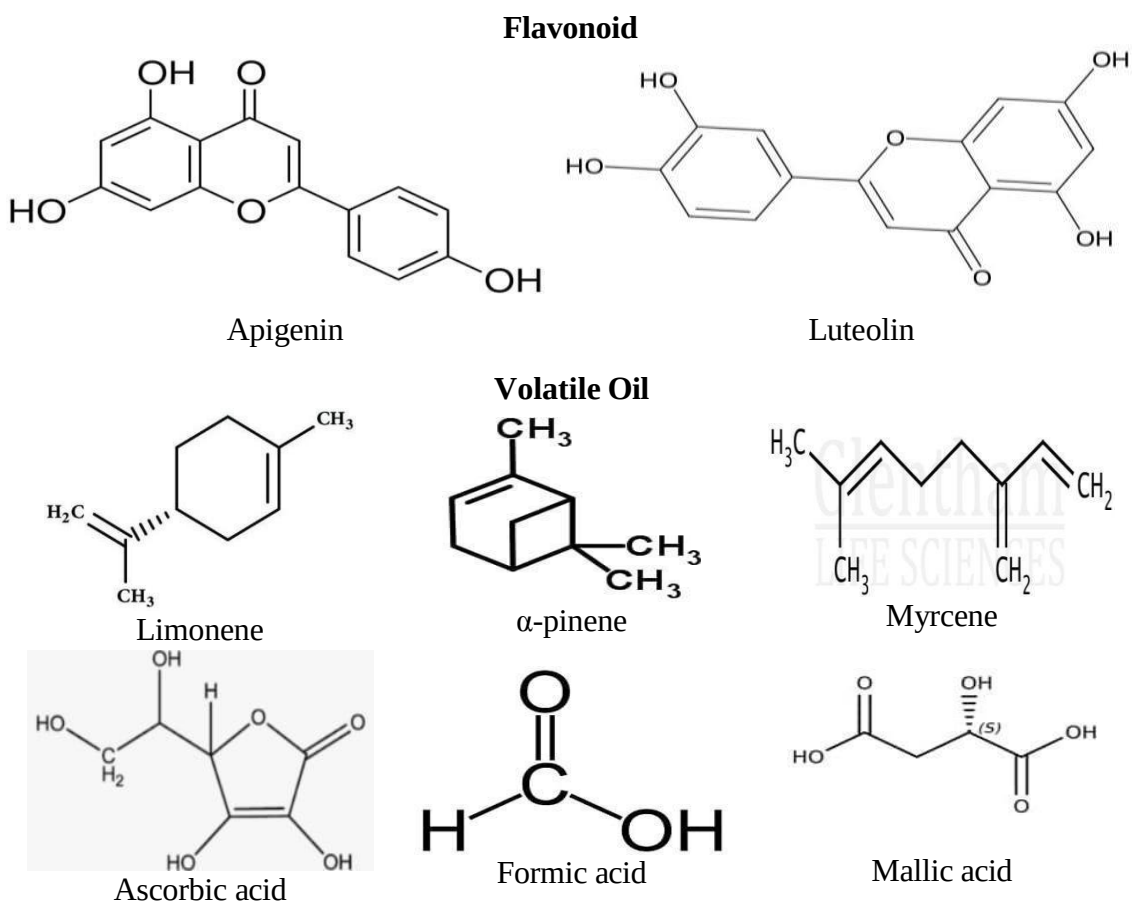
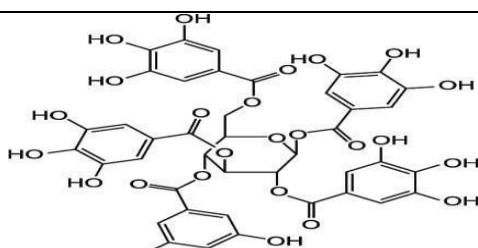
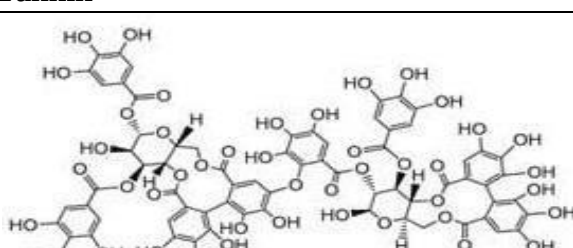
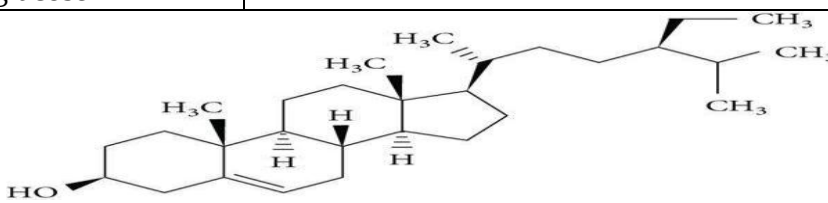
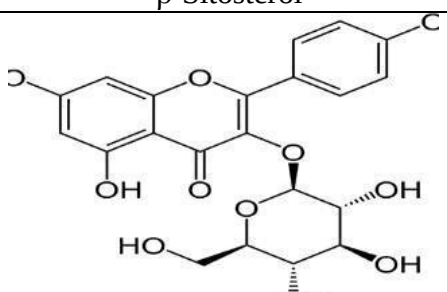
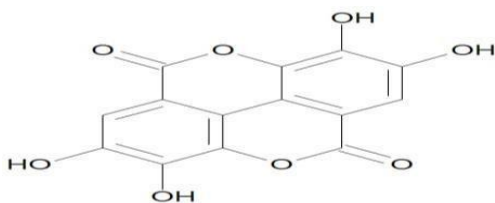


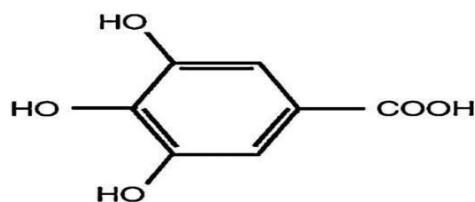
Fig 2. Chemical structures of key bioactive phytochemicals from berries of *J. communis*.

Tannin	
 1,2,3,4,6-penta-O-galloyl-beta-D-glucose	 Oenothlein B
Phytosterol	 β-Sitosterol
Glycoside	 Astragalin.

Phenolic

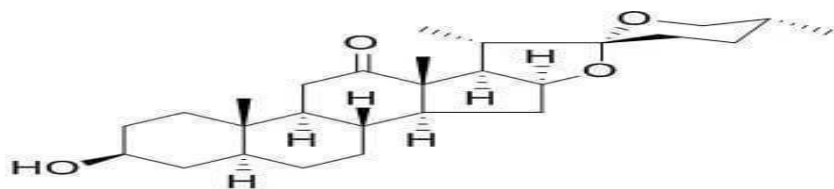


Ellagic acid



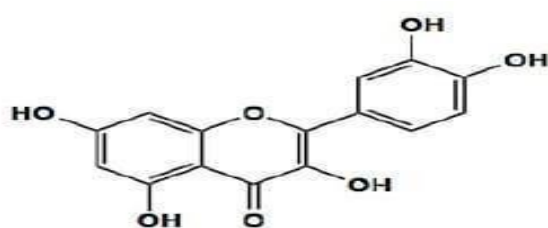
Gallic acid

Steroid

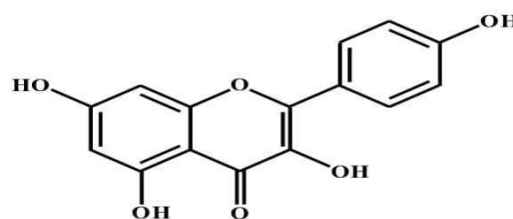


Hecogenin

Flavonoid

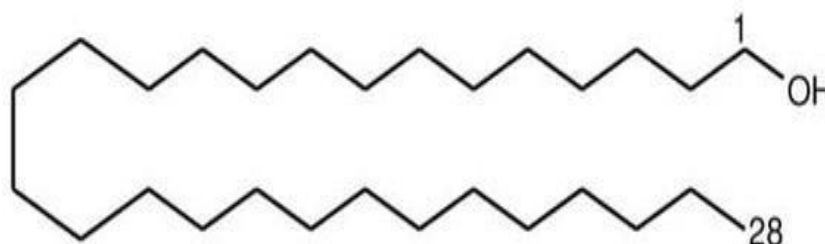


Quercetin



Kaempferol

Fatty Alcohol



Octacosanol

Fig 3. Chemical structures of key bioactive phytochemicals from flowers of *W. fruticosa*.

Pharmacological Activities of *Khajurasava* Ingredients for TB

Effective management of TB and its complications involves evaluating drugs for various pharmacological activities, including anti-inflammatory, antioxidant, hepatoprotective, and immunomodulatory effects. The plant ingredients in *Khajurasava* have been extensively studied for these activities through in vitro, in vivo, and clinical research. These studies provide substantial evidence of their efficacy in addressing both the underlying mechanisms of TB and its associated complications.

Table 3: Pharmacological Activities of *Khajurasava* in TB.

Action	Extract	Method used	Significant outcomes	References
Phoenix dactylifera	Khadhouri cultivar extract	DPPH, ABTS, IC50	highest phenolic (9.532 g/100 g) and flavonoid (3.82 g/100 g) content	[52]
	Lyophilized aqueous & ethanolic extracts	Radical Scavenging Assays	Aqueous inhibition: 19.52–79.32%; ethanolic: 10–66.51% (6.5–100 mg).	[53]
	Hydroethanolic extract	1,1-Diphenyl-2 Picrylhydrazyl (DPPH) test	Potent DPPH radical scavenging (IC50 = 0.15 mg/mL)	[54]
	Aqueous fruit extract	In vitro	Inhibited hydroxyl and superoxide radicals dose-dependently	[55]
	Essential oil from date palm	In vitro	IC50 = 0.61 µg/mL	

		spathe			
Hepatoprotective Effect		Aqueous extracts of flesh and pits	CCl4-induced hepatotoxicity in rats	Decreased bilirubin, liver enzymes, and improved histology	[56]
		Ajwa date extract	CCl4-induced toxicity	reduced serum ALP, ALT, AST, triglycerides, total cholesterol, and LDL.	[57]
		Date fruit extract	Dimethoate-induced toxicity in rats	Reduced lipid peroxidation, improved liver function and antioxidant status.	[58]
		Ethanol & aqueous extracts (300 mg/kg)	Rabbits (azithromycin toxicity)	Improved liver/kidney function; better lipid profile	[59]
		Flesh and pit extracts	Rats (CCl4-induced fibrosis)	Reduced caspase-3, Bax, Fas, CYP2E1; increased HO-1, HGF, Bcl2	[60]
		Seed aqueous suspension & proanthocyanidin- rich extract	Rats (CCl4 model)	Improved liver function and oxidative status; reduced DNA damage	[61,62,63]
		Aqueous extract	Rats (trichloroacetic acid-induced injury)	Reduced lipid peroxidation, enhanced antioxidant enzymes, improved liver histology	
Lung protective effect		Date palm sap	Bleomycin-induced lung fibrosis in rats	Normalized oxidative stress enzymes, reduced collagen accumulation	[64]
Immunomodulatory Effect		Hot aqueous extract of matured fruit	Mite-sensitized mice study	Reduced sneezing, IgE levels, IL-4+, CD4+, FcER1a cells	[65]
		Date extract	Immune cell activation study	Increased IFN- γ , IL-12, CD49b+, CD11b+;	[66]
Anti-inflammatory				trypsin-treated extract enhanced immune response	
		Hydroethanolic extract (parthenocarpic date)	Mice (carrageenan-induced paw edema)	Inhibited PLA2 (IC ₅₀ = 130 μ g/mL); reduced inflammation	[67]
		Date syrup polyphenols	TNF- α induced inflammation, angiogenesis assays	Reduced inflammation and angiogenesis markers like VEGF and COX-2 expression.	[68]
		Seed extract	RAW 264.7 cells (LPS-IFN- γ induced)	Altered metabolome suggesting anti-inflammatory potential	[69]
		Steeped seed extract (5 g/kg)	CCl4-induced inflammation in rats	Increased GSH reductase, IFN- γ ; decreased TNF- α	[70]
Hepatoprotective		Ethanol and aqueous extract	CCl4 -induced	↓ SGOT, SGPT, ALP, TB;	[71]

			hepatotoxicity in rats (9 days)	protection of hepatic cells (comparable to silymarin)	
	Anti-inflammatory	Aqueous extract	Isolated cells; Prostaglandin inhibition (0.2 mg/mL); PAF-exocytosis (0.25 mg/mL)	55% prostaglandin inhibition; 78% PAF-exocytosis inhibition (via elastase activity)	[72]
	Antioxidant	Oil extract	In vitro (DPPH, superoxide, ABTS, hydroxyl radical scavenging); In vivo (yeast)	Free radical scavenging; ↑ antioxidant enzymes; reduced oxidative stress	[73]
<i>Woodfordia fruticosa</i>	Immunomodulatory	Ethanol extract of flowers	In vitro: murine peritoneal macrophage phagocytosis and bone marrow proliferation (SRB assay)	60% increase in bone marrow cell proliferation; stimulation of bone marrow	[74]
	Hepatoprotective	Petroleum ether, alcohol, chloroform, aqueous, and methanolic extracts of flowers	Phenytoin-, CCl ₄ , acetaminophen-, and diclofenac sodium-induced hepatotoxicity in rats	Demonstrated epatoprotective effects across all extracts; effective against multiple hepatotoxic models	[75,76]
	Antioxidant	Petroleum ether, chloroform, and methanol extracts of flowers	In vitro: ABTS and DPPH free radical scavenging assays	Showed significant antioxidant activity	[77]
	Anti-inflammatory	Methanolic extract of flowers	Carrageenan, histamine, dextran, serotonin, and formaldehyde-induced inflammation in rats	Significant anti-inflammatory activity observed	[78]

DISCUSSION

A comprehensive review of the plant constituents of *Khajurasava* revealed pharmacologically active compounds with potential benefits against tuberculosis and its complications, as substantiated by in vitro, in vivo, and preliminary clinical studies.

P. dactylifera contains a rich matrix of bioactives including phenolic acids, flavonoids, proanthocyanidins, and carotenoids. These constituents demonstrate potent antioxidant potential by scavenging free radicals and upregulating endogenous antioxidant enzymes like SOD, CAT, and GSH. This antioxidant defense is critical in TB, where elevated reactive oxygen species (ROS) contribute to tissue necrosis and fibrosis. In bleomycin-induced

pulmonary fibrosis models, date palm sap has been shown to reduce collagen deposition and normalize oxidative stress markers, indicating its potential to alleviate lung damage and fibrosis associated with chronic pulmonary infections like TB. Furthermore, the anti-inflammatory effects of *P. dactylifera*, shown through inhibition of PLA2 and suppression of TNF- α and COX-2 pathways, aid in modulating the hyperinflammatory state associated with TB pathology. Its immunomodulatory properties—enhancing Th1 cytokines (IFN- γ , IL-12) and activating NK cells (CD49b⁺, CD11b⁺)—suggest its potential to support host defense against mycobacterial infection. Additionally, its hepatoprotective effect, demonstrated in multiple toxin-induced liver injury models, supports its utility in mitigating ATT-related liver damage.

J. communis also displays extensive pharmacological activity. Its antioxidant effect is mediated by monoterpenes and flavonoids, which scavenge oxidative radicals and enhance antioxidant enzyme activity. The anti-inflammatory effects, primarily through prostaglandin and PAF pathway inhibition, help reduce pulmonary and systemic inflammation. *J. communis* has also shown hepatoprotective properties in CCl₄-induced toxicity models, where it preserved liver architecture and normalized serum liver enzymes. Although direct evidence for immunomodulation is limited, its detoxifying and anti-inflammatory effects indirectly contribute to immune system stabilization, an essential factor in TB recovery.

W. fruticosa, while classically used as a fermentation starter, is pharmacologically active due to its high content of tannins and flavonoids such as oenothien B, ellagic acid, and woodfordin derivatives. These compounds possess significant antioxidant capabilities, protecting tissues from oxidative stress. Its anti-inflammatory action has been demonstrated in several models, including carrageenan and histamine-induced inflammation. Immunologically, *W. fruticosa* enhances macrophage activity and bone marrow cell proliferation, which are essential in restoring immune function in immunocompromised TB patients. Furthermore, it exhibits hepatoprotective effects in drug-induced liver damage, making it beneficial for patients receiving hepatotoxic ATT.

Taken together, the integration of these ingredients in Khajurasava creates a pharmacologically balanced formulation suitable for managing TB complications. Despite the absence of a direct formulation-based mechanistic study, collectively address the complications associated with both tuberculosis and its conventional treatment. Further research—using in vitro macrophage infection models, in vivo pulmonary TB studies, and

clinical trials—should be undertaken to validate Khajurasava as a safe and effective integrative therapy alongside modern anti-TB regimens. Such studies could not only confirm its role in organ protection but also in enhancing host immunity and improving treatment compliance.

CONCLUSION

Khajurasava holds potential as a supportive formulation in the integrative management of TB (Rajayakshma), owing to the synergistic actions of its constituents. These exhibit overlapping effects in four key therapeutic domains-antioxidant defense, inflammation modulation, immune enhancement, and hepatoprotection all crucial in addressing the multifaceted pathology of TB. This evidence-based appraisal reinforces its traditional use and supports its consideration as an adjunct to ATT.

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