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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: *Rajayakshma, Kharjur*a, Phytoconstituents, Fermented Formulation.

INTRODUCTION

Rajayakshma is primarily attributable to *Dhatukshaya* (tissue emaciation or loss). This process universally initiates the process of pathogenesis in *Rajayakshma* 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 occur 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 *Rajayakshma* 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.

*Khajurasav*a, 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).

There fore, 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, Yogaratnakara, 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.*[11]	Carminative, urinary antiseptic, diuretic, emmenagogue, sudorific, digestive, and anti-inflammatory,[12,13]
2.	*Dhataki*	*Southern Asia: (Bhutan, China (Yunnan, Guangdong, Guangxi), Japan, India, Myanmar (Burma), Nepal,Vietnam, Malaysia, Pakistan, Sri Lanka), Gulf Nations: (Saudi Arabia (Southwest – Asir region), Oman (Dhofar region), Other Regions: (Java, Sumatra, Madagascar, Tanzania, Comores).*[14,15]	Sunstroke, Cold.[16]Wound healing.[17] Leucoderma (Kondha tribe of Orissa).[18] Ulcers (*Vrana*).[19] Rheumaic pain (southern part).[20] Toothache, Blood infection, Leprosy, Dysentery, Pediatric diarrhoea. Fever, urinary disorder, swelling, menstrual problems (Nepal).[21]

***Phytochem*istry**

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 oenothein B, woodfordin derivatives, ellagic acid, kaempferol, quercetin, β-sitosterol, astragalin, and chrysophanol glucoside, identified through HPLC, UV-Vis, NMR, IR, and MS.

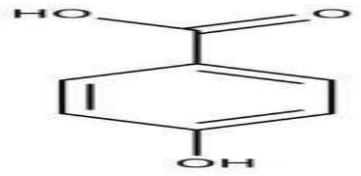
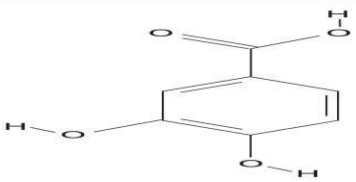
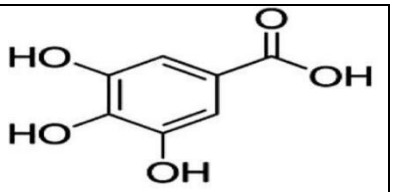
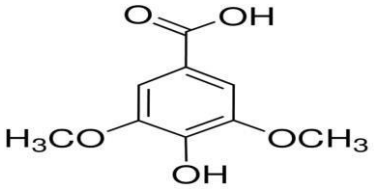
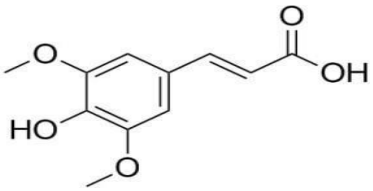
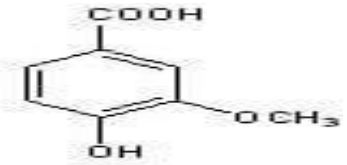
Table 2: List of phytoconstituents isolated from the specific plant parts used in *Khajurasava*.

Phoenix dactylifera	**Classification**	**Isolated compound name**	**Method of characterization**	**Reference**
	Phenolic Acids	**Bezoic 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 deivatives : Caffeic acid, p-Coumaric acid, Ferulic acid, Hydrocaffeic acid, Dactyliferic acid, 3/4/5-Caffeoylshikimic acid, Dicaffeoylsinapoyl hexoside	HPLC, LC-MS/MS	
	Flavonoid glycosides and esters	Rutin, luteolin, apigenin, quercetin (and its derivatives: hexoside sulfate, acetyl-hexoside, rhamnosyl-hexoside), isorhamnetin derivatives (isorhamnetin hexoside,	C-MS/MS, NMR, UV-Vis, HPTLC	[22,23,24,25], [26,27,28,29,30, 31,32]

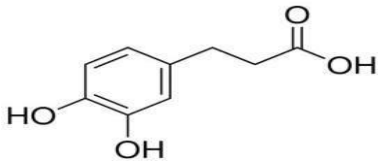
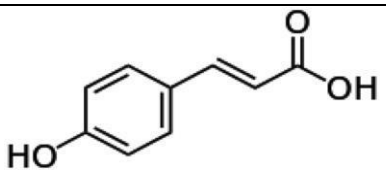
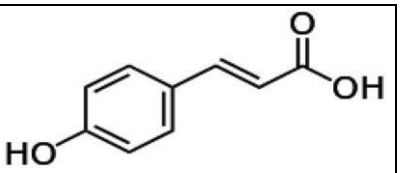
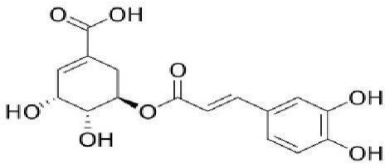
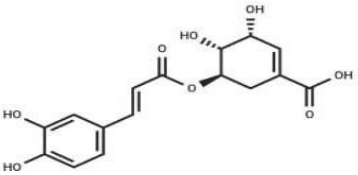
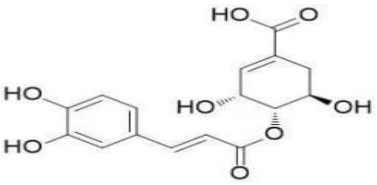
		acetyl-hexoside, 3-O-rutinoside), chrysoeriol derivatives (rhamnosyl-hexoside, hexoside sulfate, hexoside), and isoquercitrin		
	Flavan -3-ols	Catechin (+), Epicatechin (-)	HPLC, LC-MS	[22,23,24,25] [26,27,28,29,30]
	Proanthocyanidins	Procyanidin B1, B2, Trimer, Tetramer, Pentamer	HPLC, MS	[22,23,24,25] [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]
Juniperus communis	**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/MS,NMR	[35,36,37,38,39,40]
	Volatile oils	**Berry oil :** a-Pinene (51.4%), Sabinene (5.8%), β-Pinene (5.0%), Myrcene (8.3%), Limonene (5.1%)	GC-MS	[41,42]
		d-a-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]
Woodfordia fruticosa	**Classification**	**Isolated compound name**	**Method of characterization**	**Reference**
		1,2,3,4,6-penta-O-galloyl-β-D-glucose,		
	Tannin	1,2,3,6-tetra-O-galloyl-β-D-glucose, Gemin D, Heterophylliin A, Oenothein B, Oenothein C, Woodfordin A-I, Woodfructosin, Tellimagrandin,	HPLC, NMR, MS, UV-Vis spectroscopy	[43,44,45,46]
		Isoschimawalin A		
			GC-MS, IR	
	Phytosterol	β-Sitosterol	spectroscopy,	[47]
			NMR	
		Astragalin, Kaempferol-3-glucoside,		
	Glycoside	Chrysophanol-8-O-β-D-glucopyranosid e, Juglalin, Kaempferol 3-O-arabinoside, Kaempferol	C, LC-MS, NMR	[47,48]
		3-O-(6”-galloyl)-β-D-Glucopyranoside		
	Phenolic	Ellagic acid, Gallic acid	UV-Vis, HPLC,	[49,50]
			FTIR	[51]
	Steroid	Hecogenin	GC-MS, IR,	[50]
			NMR	

	Flavonoid	Kaempferol, Quercetin	HPLC, UV-Vis, LC-MS	[49]
	Fatty alcohol	Octacosanol	GC-MS, NMR, IR	[47]

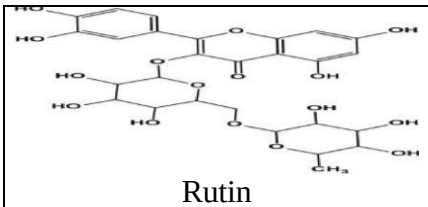
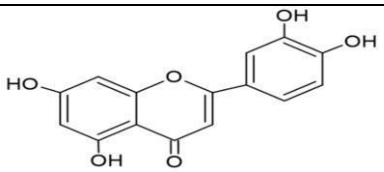
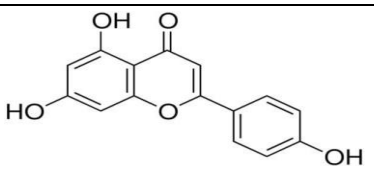
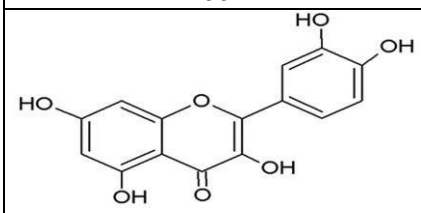
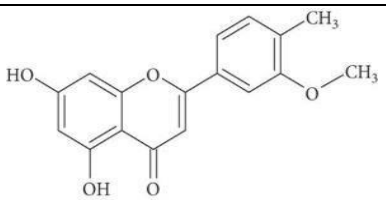
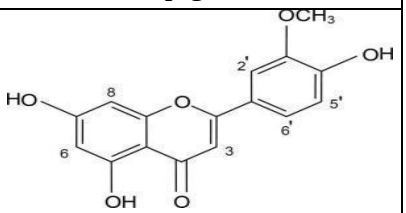
Benzoic acids and derivatives

 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
 Quercetin	 Isorhamnetic	 Chrysoeriol

Proanhocynidins

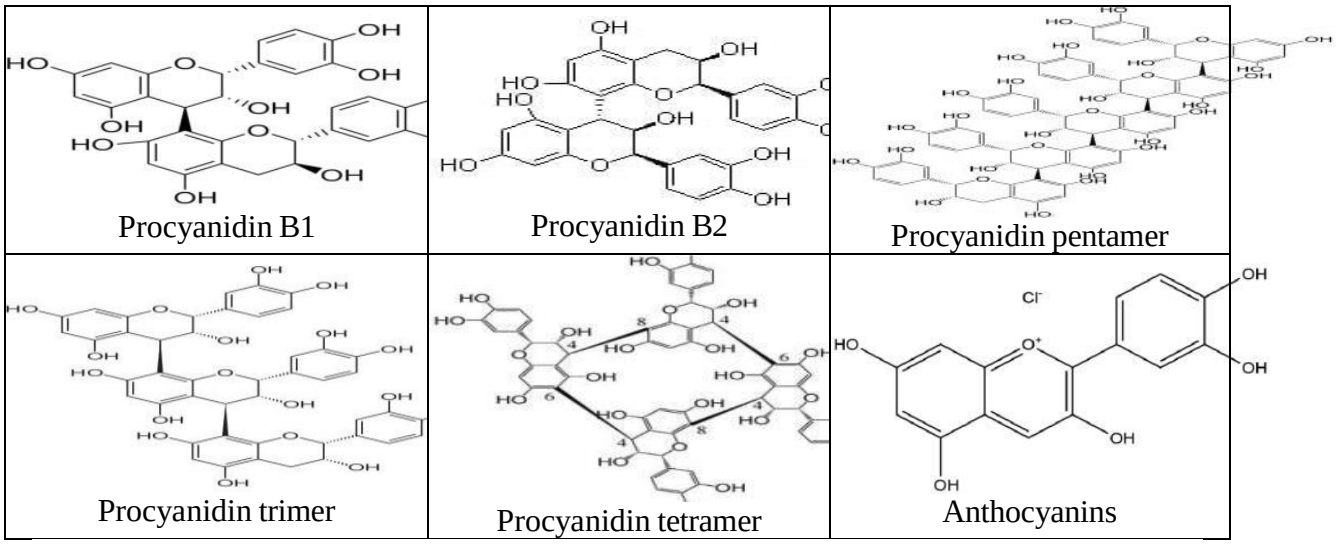
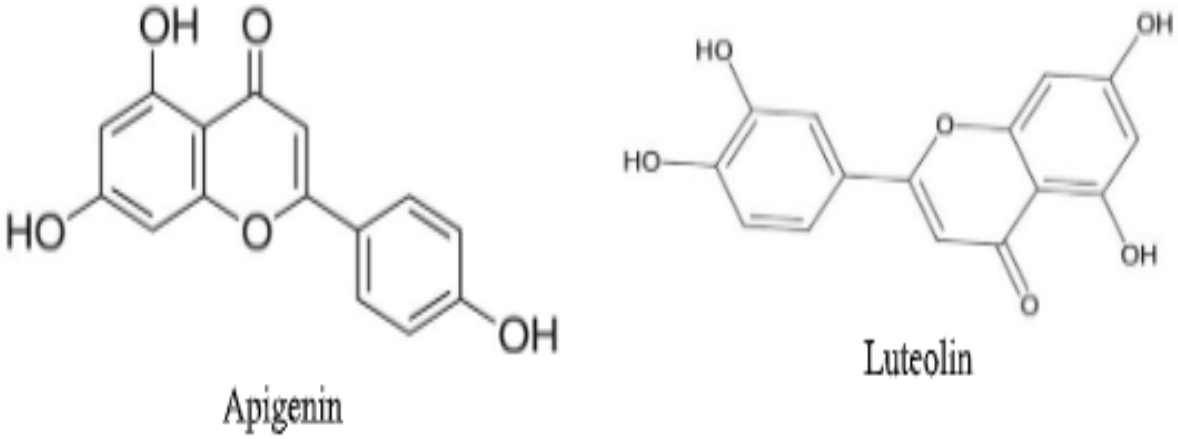


Fig 1: Chemical structures of key bioactive phytochemicals from fruit of *P. dactylifera.*

Flavonoid



Volatile Oil

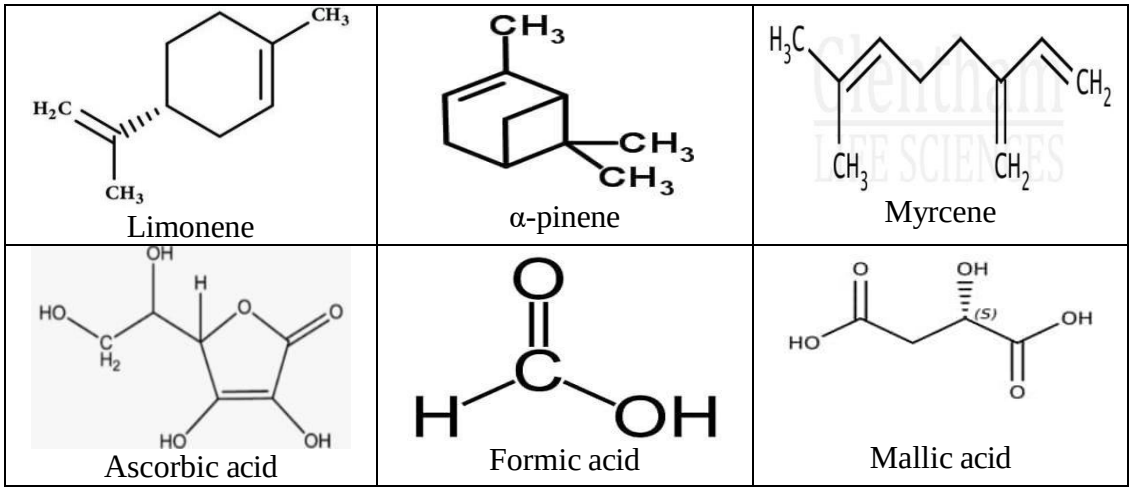
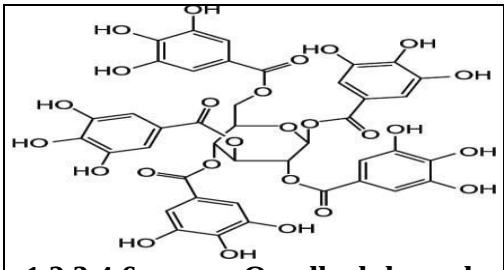


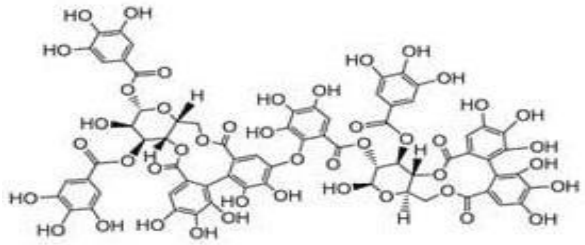
Fig 2: Chemical structures of key bioactive phytochemicals from berries of *J.communis.*

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

Tannin

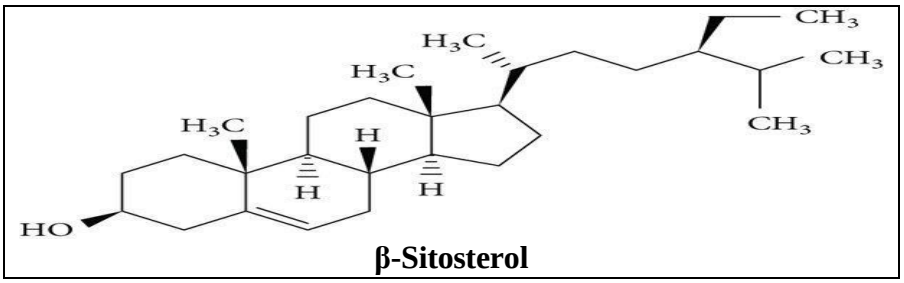


1,2,3,4,6-penta -O-galloyl -beta-d-glucose



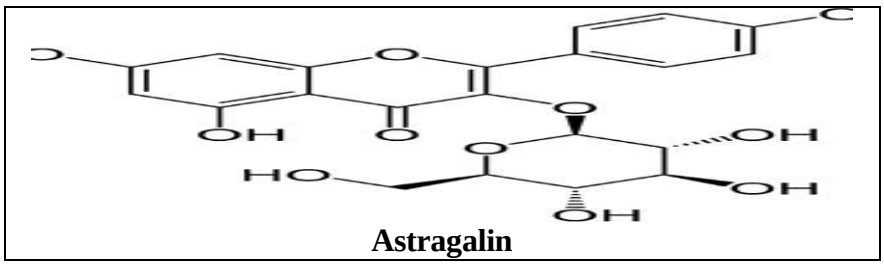
Oenothein B

Phytosterol



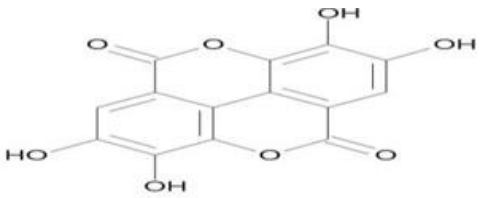
β-Sitosterol

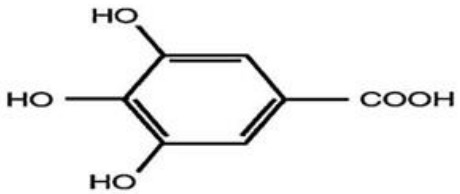
Glycoside



Astragalin

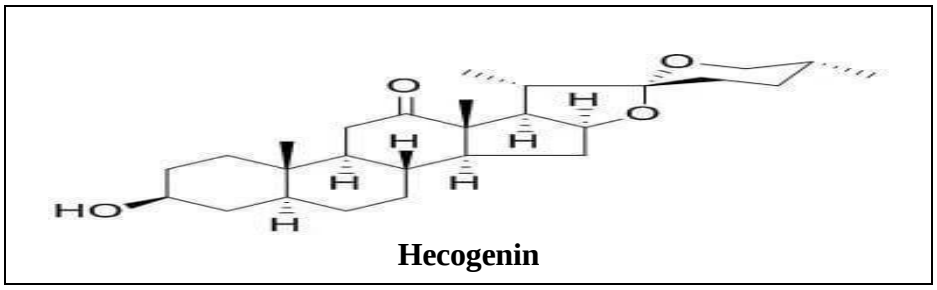
Phenolic





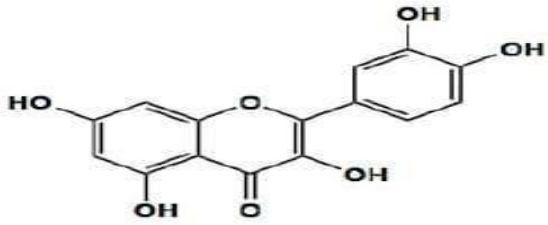
Ellagic acid Gallic acid.

Steroid

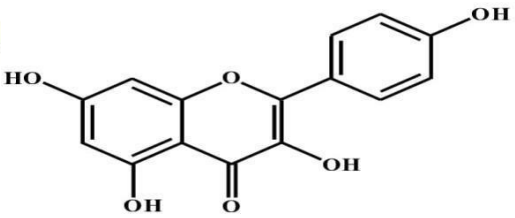


Hecogenin

Flavonoid

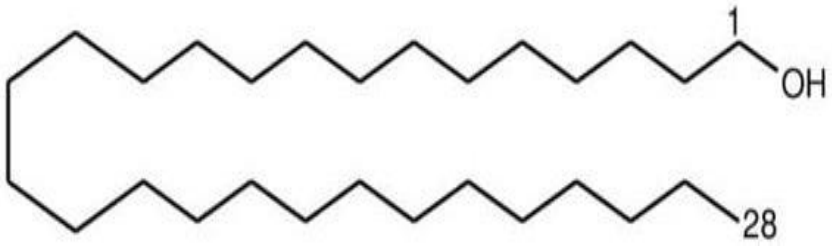


Querceti



Kaempferol

Fatty Alcohol



Octacosanol

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	Anti-oxidant	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 spathe	In vitro	IC50 = 0.61 µg/mL	

	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-induce d toxicity in rats	Reduced lipid peroxidation, improved liver function and antioxidant status.	[58]
		Ethanolic & 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-inducedinjury)	Reduced lipid peroxidation, enhanced antioxidant enzymes, improved liver histology	
	Lung protec tive effect	Date palm sap	Bleomycin-induced lung fibrosis in rats	Normalized oxidative stress enzymes, reduced collagen accumulation	[64]
	Immunomo dulatory Effect	Hot aqueous extract of matured fruit	Mite-sensitized mice study	Reduced sneezing, IgE levels, IL-4+, CD4+, FcERIa cells	[65]
		Date extract	Immune cell activation study	Increased IFN-γ, IL-12, CD49b+, CD11b+;	[66]
				trypsin-treated extract enhanced immune response	
	Anti-inflammatory	Hydroethanolic extract (parthenocarpic date)	Mice (carrageenan-induc ed paw edema)	Inhibited PLA2 (IC50 = 130 µg/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]

Juniperus communis	Hepatoprotective	Ethanol and aqueous extract	CCl4 -induced hepatotoxicity in rats (9 days)	↓ SGOT, SGPT, ALP, TB; protection of hepatic cells (comparable to silymarin)	[71]
	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]
Woodfordia fruticosa	Immunomodulatory	Ethanolic 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-, CCI4, acetaminophen-, and diclofenac sodium-induced hepatotoxicity in rats	Demonstrated hepatoprotectiv e 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-inflammat ory 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 oenothein 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 ingrdients 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.

REFERENCES

1. Samhita A. In: Panduranga PS, editor. Bombay: Government Central Book Depot; 1973.
2. Wrigley G. Date palm. In: Evolution of Crop Plants. Edited by: J.Smartt and N.W. Simmonds. 2nd ed. Essex, UK: Longman Group, 1995. ISBN:978-05820864326.
3. Nixon RW. The date palm "Tree of life" in the subtropical deserts. Econ Bot., 1951; 5(3): 274-301. Available at:http://doi.org/10.1007/BF02985151
4. 7. Chao CT, Krueger RR. The date palm (Phoenix dactylifera L.): overview of biology, uses, and cultivation. Horts, 2007; 42(5): 1077-1082. Available at: http://doi.org/10.21273/HORTSCI.42.5.1077
5. Tahraoui A, El-Hilaly J, Israili ZH, Lyoussi B. Ethnopharmacological survey of plants used in the traditional treatment of hypertension and diabetes in south-eastern Morocco (Errachidia Province).J Ethnopharm 2007; 110(1): 105-117. Available at: http://doi.org/10.1016/j.jep.2006.09.011
6. Selvam ABD. Inventory of vegetable crude drug samples housed in botanical survey of India, Howrah. Pharmy Rev., 2008; 2: 61-94. Available at: https://www.phcogrev.com/article/2008/2/3-5
7. Khare CP. Indian Medicinal Plants: An Illustrated Dictionary. Berlin, Germany: Springer Science, Springer Verlag, 2007: 453. Available at:https://doi.org/10.1007/978-0-387-70638-2

8. Al-Mamary M, Al-Habori M, Al-Zubairi AS. The in vitro antioxidant activity of different types of palm dates (Phoenix dactylifera) syrups. Arab J Chem., 2014; 7(6): 964-971. Available at: http://doi.org/10.1016/j.arabjc.2010.11.014
9. Elberry AA, Mufti ST, Al-Maghrabi JA, et al. Anti-inflammatory and antiproliferative activities of date palm pollen (Phoenix dactylifera) on experimentally-induced atypical prostatic hyperplasia in rats. J Inflam 2011; 8(1): 40.Available at:http://doi.org/10.1186/1476-9255-8-40
10. Hassan HM. Chemical composition and nutritional value of palm pollen grains. Global J Biotechnol Biochem 2011; 6(1): 1-7. Available at: https://www.idosi.org/gjbb/gjbb6(1)11/1.pdf
11. Sharma P. K., Lal B. Ethnobotanical notes on some medicinal and aromatic plants of Himachal Pradesh. Indian journal of Traditional Knowledge. 2005; 4(4): 424–428.
12. Gumral N., Kumbul D. D., Aylak F., Saygin M., Savik E. Juniperus communis Linn oil decreases oxidative stress and increases antioxidant enzymes in the heart of rats administered a diet rich in cholesterol. Toxicology and Industrial Health. 2013 doi: 10.1177/0748233712469995.
13. Banerjee S., Singh H., Chatterjee T. K. Evaluation of anti-diabetic and anti-hyperlipidemic potential of methanolic extract of Juniperus Communis (L.) in streptozotocinnicotinamide induced diabetic rats. International Journal of Pharma and Bio Sciences. 2013; 4(3): P10–P17.
14. Baravalia Y, Nagani K, Chanda S. Evaluation of pharmacognostic and physicochemical parameters of Woodfordia fruticosa Kurz. flowers. Pharmacogn, 2011; 2(18): 13-8.
15. Bhattarai S, Bhuju DR. Medicinal usefulness of Woodfordia fruticosa (Linn.) Kurz. of Nepal. Ethnomedicinal plants: Revitalization of traditional knowledge of herbs. Science Publishers New York: CRC press, 2011; 253-68.
16. Murad W, Ahmad A, Gilani SA, Khan MA. Indigenous knowledge and folk use of medicinal plants by the tribal communities of Hazar Nao Forest, Malakand District, North Pakistan. J Med Plant Res, 2011; 5(7): 1072-86.
17. Wayal SR, Gurav SS. Pharmacognostic and phytochemical investigation of potentially important plants of Western Ghats, India. Int J Pharm Sci Res., 2019; 10(6): 3101-8.
18. Mohapatra SP, Sahoo HP. Some lesser known medicinal plants of the Kondha and Gond tribes of Bolangir, Orissa, India. Ethnobotanical leaflets., 2008; 2008(1): 1003-6.
19. The Ayurvedic Pharmacopoeia. Ayurvedic Pharmacopoeia India Part-I. Government of India, 2013.

20. Jeyaprakash K, Ayyanar M, Geetha KN, Sekar T. Traditional uses of medicinal plants among the tribal people in Theni District (Western Ghats), Southern India. Asian Pac J Trop Biomed, 2011; 1(1): S20-5.
21. Bhattarai S, Bhuju DR. Medicinal usefulness of Woodfordia fruticosa (Linn.) Kurz. of Nepal. Ethnomedicinal plants: Revitalization of traditional knowledge of herbs. Science Publishers New York: CRC press, 2011; 253-68.
22. Al-Shwych H. Date palm (Phoenix dactylifera L.) fruit as potential antioxidant and antimicrobial agents. J Pharm Bioall Sci 2019; 11(1): 1. Available at:http://doi.org/10.4103/JPBS.JPBS_168_18
23. Ghnimi S, Umer S, Karim A, Kamal-Eldin A. Date fruit (Phoenix dactylifera L.): an underutilized food seeking industrial valorization. NFS J 2017; 6: 1-10. Available at: http://doi.org/10.1016/j.nfs.2016.12.001
24. Maier VP, Metzler DM. Changes in Individual Date Polyphenols and Their Relation to Browning. J Food Sci., 1965; 30(5): 747-752. Available at:http://doi.org/10.1111/j.1365-2621.1965.tb01835.x
25. Mansouri A, Embarek G, Kokkalou E, Kefalas P. Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit. (Phoenix dactylifera). Food Chem., 2005; 89(3): 411-420. Available at:http://doi.org/10.1016/j.foodchem.2004.02.051
26. Maier VP, Metzler DM, Huber AF. 3-0-Caffeoylshikimic acid (dactylifric acid) and its isomers, a new class of enzymic browning substrates. Biochem Biophys Res Commun, 1964; 14(2): 124-128. Available at:http://doi.org/10.1016/0006-291X(64)90241-4
27. Al-Farsi M, Alasalvar C, Morris A, Baron M, Shahidi F. Comparison of Antioxidant Activity, Anthocyanins, Carotenoids, and Phenolics of Three Native Fresh and Sun-Dried Date (Phoenix dactylifera L.) Varieties Grown in Oman. J Agric Food Chem., 2005; 53(19): 7592-7599. Available at: http://doi.org/10.1021/jf050579q
28. Borochov-Neori H, Judeinstein S, Greenberg A, et al. Date (Phoenix dactylifera L.) Fruit Soluble Phenolics Composition and Anti-atherogenic Properties in Nine Israeli Varieties. J Agric Food Chem., 2013; 61(18): 4278-4286. Available at: http://doi.org/10.1021/jf400782v
29. Hammouda H, Chérif JK, Trabelsi-Ayadi M, Baron A, Guyot S.Detailed Polyphenol and Tannin Composition and Its Variability in Tunisian Dates (Phoenix dactylifera L.) at Different Maturity Stages. J Agric Food Chem., 2013; 61(13): 3252-3263. Available at: http://doi.org/10.1021/jf30461
30. Hong YJ, Tomas-Barberan FA, Kader AA, Mitchell AE. The Flavonoid Glycosides and

Procyanidin Composition of Deglet Noor Dates (Phoenix dactylifera). J Agric Food Chem., 2006; 54(6): 2405-2411. Available at: http://doi.org/10.1021/jf0581776

31. Ammar NM, Abou El-Kassem LT, El-Sayed NH, et al. Flavonoid Constituents and Antimicrobial Activity of Date (Phoenix dactylifera L.) Seeds Growing in Egypt. Med Aromat Plant Sci Biotechnol, 2009; 3(special issue 1):1–5. Available at: http://www.globalsciencebooks.info/Online/GSBOnline/images/0906/MAPSB_3(SI1)/MAPSB_3(SI1)1-5o.pdf
32. Bouhlali E dine T, Hmidani A, Bourkhis B, et al. Effect of Phoenix dactylifera seeds (dates) extract in triton WR-1339 and high fat diet induced hyperlipidaemia in rats: a comparison with simvastatin. J Ethnopharm, 2020; 259: 112961. Available at:http://doi.org/10.1016/j.jep.2020.112961
33. Rygg Gl. Compositional changes in the date fruits during growth and ripening USDA. Tech Bull 1946; 910: 51. Available at: https://naldc.nal.usda.gov/download/CAT86200902/PDF
34. Tyler VE, Brady LR, Robbers JE. Pharmacognosy. 9th ed. Lea and Febriger, Philadelphia, 1988; 54–56. Available at: ISBN: 9780812110715
35. Lamer Zarawska E. Biflavonoids in Juniperus species (Cupressaceae) Polish Journal of Pharmacology and Pharmacy, 1975; 27(1): 81–87.
36. Lamer-Zarawska E. Phytochemical studies on flavonoids and other compounds of juniper fruits. Polish Journal of Chemistry. 1980; 54(2): 213–219.
37. Hiermann A., Kompek A., Reiner J., Auer H., Schubert-Zsilavecz M. Investigation of flavonoid pattern in fruits of juniperus communis L. Scientia Pharmaceutica. 1996; 64(3-4): 437–444.
38. Kowalska M. Chemical composition of common juniper (J. communis L.) fruits. Roczniki Akademii Rolniczej w Poznaniu. 1980; 117: 61–64.
39. Lamer-Zarawska E. Flavonoids of J. communis L. Roczniki Chemii, 1977; 51(11): 2131– 2137.
40. Ilyas M., Ilyas N. Biflavones from the leaves of J. communis and a survey on biflavones of the Juniperus genus. Ghana Journal of Chemistry. 1990; 1(2): 143–147. (CA 252113, 1991, vol. 115)
41. Hoferl M., Stoilova I., Schmidt E., et al. Chemical composition and antioxidant properties of Juniper Berry (J. communis L.) Essential oil. Action of the essential oil on the antioxidant protection of Saccharomyces cerevisiae model organism. Antioxidants, 2014; 3(1): 81–98. doi: 10.3390/antiox3010081.

42. Chandra K., Chaudhari B. G., Dhar B. P., et al. Database in Medicinal Plants Used in Ayurveda. (3rd) 2007; 5.
43. Yoshida T, Chou T, Nitta A, Miyamoto K, Koshiura R, Okuda T. Woodfordin C, a macro-ring hydrolyzable tannin dimer with antitumor activity, and accompanying dimers from Woodfordia fruticosa flowers. Chem Pharm Bull, 1990; 38(5): 1211-7.
44. Yoshida T, Chou T, Nitta A, Okuda T. Tannins and related polyphenols of Lythraceous plants. III. Hydrolyzable tannin oligomers with macrocyclic structures, and accompanying tannins from Woodfordia fruticosa Kurz. Chem Pharm Bull, 1992; 40(8): 2023-30.
45. Yoshida T, Chou T, Matsuda M, Yasuhara T, Yazaki K, Hatano T, et al. Woodfordin D and oenothein A, trimeric hydrolyzable tannins of macro-ring structure with anti-tumor activity. Chem Pharm Bull, 1991; 39(5): 1157-62.
46. Kadota S, Takamori Y, Nyein KN, Kikuchi T, Tanaka K, Ekimoto H. Constituents of the leaves of Woodfordia fruticosaKurz. I: Isolation, structure and proton and carbon-13 nuclear magnetic resonance signal assignments of Woodfruticosin (Woodfordin C), an inhibitor of deoxyribonucleic acid topoisomerase II. Chem Pharm Bull, 1990; 38: 2687-97.
47. Chauhan JS, Srivastava SK. Phytochemical investigation of the flowers of Woodfordia fruticosa. Planta Med., 1979; 36(06): 183-4.
48. Lee YE, Kodama T, Win NN, Ki DW, Hoang NN, Wong CP, et al. Flavonoids from Woodfordia fruticosa as potential SmltD inhibitors in the alternative biosynthetic pathway of peptidoglycan. Bioorg Med Chem Lett, 2021; 36: 127787.
49. Khan IA, Singh A, Mindala DP, Meena S, Vij B, Yadav AK, et al. Preclinical development of gastro-protective botanical candidate from Woodfordia fruticosa (Linn.) Kurz: Chemical standardization, efficacy, pharmacokinetics and safety pharmacology. J Ethnopharmacol, 2019; 241: 112023.
50. Raghuwanshi N, Yadav TC, Srivastava AK, Raj U, Varadwaj P, Pruthi V. Structure-based drug designing and identification of Woodfordia fruticosa inhibitors targeted against heat shock protein (HSP70-1) as suppressor for Imiquimod-induced psoriasis like skin inflammation in mice model. Mater Sci Eng C Mater Biol Appl, 2019; 95: 57-71.
51. Syed YH, Khan M. Chromatographic profiling of ellagic acid in Woodfordia fruticosa flowers and their gastroprotective potential in ethanol-induced ulcers in rats. Pharmacogn Res, 2016; 8(Suppl 1): S5-11.
52. Taleb H, Maddocks SE, Morris RK, Kanekanian AD. Chemical characterisation and the anti-inflammatory, anti-angiogenic and antibacterial properties of date fruit (Phoenix

dactylifera L.). J Ethnopharmacol, 2016; 194: 457–468. Available at: http://doi.org/10.1016/j.jep.2016.10.032

53. El Sohaimy SA, Abdelwahab AE, Brennan CS, et al. Phenolic content, antioxidant and antimicrobial activities of Egyptian date palm (Phoenix dactylifera L.) fruits. Aust J Basic Appl Sci, 2015; 9(1): 141–147. Available at: http://ajbasweb.com/old/ajbas/2015/141-148.pdf
54. El Abed H, Chakroun M, Abdelkafi-Koubaa Z, et al. Antioxidant, Anti-Inflammatory, and Antitumoral Effects of Aqueous Ethanolic Extract from Phoenix dactylifera L. Parthenocarpic Dates. BioMed Res Int 2018; 2018: 1–7. Available at: http://doi.org/10.1155/2018/1542602
55. Vayalil PK. Antioxidant and Antimutagenic Properties of Aqueous Extract of Date Fruit (Phoenix dactylifera L. Arecaceae). J Agric Food Chem, 2002; 50(3): 610–617. Available at: http://doi.org/10.1021/jf010716t
56. Al-Qarawi AA, Mousa HM, Ali BEH, et al. Protective effect of extracts from dates (Phoenix dactylifera L.) on carbon tetrachloride – induced hepatotoxicity in rats. Int J Appl Res Vet Med 2004; 2(3):1 76–180. Available at: http://www.jarvm.com/articles/Vol2Iss3/ELMOUGHJARVMVol2No304.pdf
57. Elsadek B, El-Sayed ES, Mansour A, et al. Abrogation of carbon tetrachloride-induced hepatotoxicity in Sprague-Dawley rats by Ajwa date fruit extract through ameliorating oxidative stress and apoptosis. Pak J Pharm Sci., 2017; 30(6): 2183–2191. Available at:https://pubmed.ncbi.nlm.nih.gov/29175788/
58. [58] Saafi EB, Louedi M, Elfeki A, et al. Protective effect of date palm fruit extract (Phoenix dactylifera L.) on dimethoate induced-oxidative stress in rat liver. Exp Toxicol Pathol, 2011; 63(5): 433–441. Available at: http://doi.org/10.1016/j.etp.2010.03.002
59. Ahmad M, Masood I, Ikram H, et al. Pharmacological Investigation of Phoenix dactylifera L. in Azithromycin Induced Toxicity. Int J Pharmacol, 2017; 14(1): 61–67. Available at: http://doi.org/10.3923/ijp.2018.61.67
60. Al-Rasheed NM, Attia HA, Mohamad RA, Al-Rasheed NM, Al Fayez M, Al-Amin MA. Date fruits inhibit hepatocyte apoptosis and modulate the expression of hepatocyte growth factor, cytochrome P450 2E1 and heme oxygenase-1 in carbon tetrachloride-induced liver fibrosis. Arch Physiol Biochem, 2016; 123(2): 78–92. Available at: http://doi.org/10.1080/13813455.2016.1251945
61. Attia H, Al-Rasheed N, Mohamad R, Al-Rasheed N, Al-Amin M. The antifibrotic and fibrolytic properties of date fruit extract via modulation of genotoxicity, tissue-inhibitor

of metalloproteinases and nuclear factor-kappa B pathway in a rat model of hepatotoxicity. BMC Complement Altern Med, 2016; 16(1). Available at: http://doi.org/10.1186/s12906-016-1388-2

62. Ahmed AF, Al-Qahtani JH, Al-Yousef HM, et al. Proanthocyanidin-Rich Date Seed Extract Protects Against Chemically Induced Hepatorenal Toxicity. J Med Food, 2015; 18(3): 280–289. Available at: http://doi.org/10.1089/jmf.2014.3157
63. Abdelaziz DHA, Ali SA. The protective effect of Phoenix dactylifera L. seeds against CCl4-induced hepatotoxicity in rats. J Ethnopharm, 2014; 155(1): 736–743. Available at:http://doi.org/10.1016/j.jep.2014.06.026
64. Bahri S, Abdennabi R, Mlika M, Neji G, Jameleddine S, Ali RB. Effect of Phoenix dactylifera L. Sap Against Bleomycin-Induced Pulmonary Fibrosis and Oxidative Stress in Rats: Phytochemical and Therapeutic Assessment. Nutr Cancer, 2019; 71(5): 781–791. Available at:http://doi.org/10.1080/01635581.2018.1521442
65. Karasawa K, Otani H. Anti-Allergic Properties of a Matured Fruit Extract of the Date Palm Tree (Phoenix dactylifera L.) in Mite-Sensitized Mice. J Nutr Sci Vitaminol, 2012; 58(4): 272– 277. Available at: http://doi.org/10.3177/jnsv.58.272
66. Karasawa K, Uzuhashi Y, Hirota M, Otani H. A Matured Fruit Extract of Date Palm Tree (Phoenix dactylifera L.) Stimulates the Cellular Immune System in Mice. J Agric Food Chem, 2011; 59(20): 11287–11293. Available at: http://doi.org/10.1021/jf2029225
67. El Abed H, Chakroun M, Abdelkafi-Koubaa Z, et al. Antioxidant, Anti-Inflammatory, and Antitumoral Effects of Aqueous Ethanolic Extract from Phoenix dactylifera L. Parthenocarpic Dates. BioMed Res Int 2018; 2018: 1–7. Available at:http://doi.org/10.1155/2018/1542602
68. Taleb H, Morris RK, Withycombe CE, Maddocks SE, Kanekanian AD. Date syrup – derived polyphenols attenuate angiogenic responses and exhibits anti-inflammatory activity mediated byvascular endothelial growth factor and cyclooxygenase-2 expression in endothelial cells. Nutr Res., 2016; 36(7): 636–647. Available at: http://doi.org/10.1016/j.nutres.2016.02.010
69. Abdul-Hamid NA, Abas F, Ismail IS, et al. 1H-NMR-based metabolomics to investigate the effects of Phoenix dactylifera seed extracts in LPS-IFN-γ-induced RAW 264.7 cells. Food Res Int., 2019; 125: 108565. Available at: http://doi.org/10.1016/j.foodres.2019.108565
70. Saryono S, Taufik A, Proverawati A, Efendi F. Dietary supplementation of Phoenix dactylifera L. seeds decreases pro-inflammatory mediators in CCl4-induced rats. J

Herbmed Pharmacol, 2019; 8(3): 212–217. Available at: http://doi.org/10.15171/jhp.2019.31

71. Manvi, Garg G. P. Screening and evaluation of pharmacognostic, phytochemical and hepatoprotective activity of J. communis L. Stems. International Journal of Pharma and Bio Sciences. 2010; 1(3).
72. Tunon H., Olavsdotter C., Bohlin L. Evaluation of anti-inflammatory activity of some Swedish medicinal plants. Inhibition of prostaglandin biosynthesis and PAF-induced exocytosis. Journal of Ethnopharmacology. 1995; 48(2): 61–76. doi: 10.1016/0378-8741(95)01285-L.
73. Hoferl M., Stoilova I., Schmidt E., et al. Chemical composition and antioxidant properties of Juniper Berry (J. communis L.) Essential oil. Action of the essential oil on the antioxidant protection of Saccharomyces cerevisiae model organism. Antioxidants. 2014; 3(1): 81–98. doi: 10.3390/antiox3010081.
74. Shah AS, Juvekar AR. In vitro and in vivo immunostimulatory activity of Woodfordia fruticosa flowers on non-specific immunity. Pharm Biol, 2010; 48(9): 1066-72.
75. Brindha D, Geetha R. Evaluation of the protective efficacy of Woodfordia fruticosa on phenytoin induced liver damage in rats. Journal of cell and tissue research. 2009 Dec 1; 9(3): 1981.
76. Baravalia Y, Vaghasiya Y, Chanda S. Hepatoprotective effect of Woodfordia fruticosa Kurz flowers on diclofenac sodium induced liver toxicity in rats. Asian Pacific Journal of Tropical Medicine. 2011 May 1; 4(5): 342-6.
77. Finose A, Devaki K. Phytochemical and Chromatographic Studies in the Flowers of Woodfordia fruticosa (L) kurz. Asian Journal of Plant Science and Research 2011; 1(3): 81-85.
78. Baravalia Y, Kumar YV, Chanda S. Brine shrimp cytotoxicity, anti-inflammatory and analgesic properties of Woodfordia fruticosa kurz flowers. Iran J Pharm Res. 2012; 11: 854-861.