

**UNLOCKING NATURE'S PHARMACOLOGICAL FRAMEWORK: AN *IN-SILICO*
EXPLORATION OF *CARICA PAPAYA* LINN'S THERAPEUTIC POTENTIAL**

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ABSTRACT

Carica papaya Linn. (CP), commonly known as papaya, is a tropical plant of considerable ethnomedicinal and nutritional importance. Traditionally utilized in Indian medicine for managing various ailments, including cancer, its fruit, leaves, and seeds have been recognized for therapeutic potential. This study investigates the pharmacological potential of *C. papaya* through an *in-silico* pharmacological and pharmacognostic approach. Phytochemicals were retrieved from curated databases, including IMPPAT, and evaluated using the SwissADME platform to assess their pharmacokinetic profiles. Key parameters analyzed included Absorption, Distribution, Metabolism, and Excretion (ADME), along with drug-likeness, lipophilicity, and solubility indices. The computational screening identified a diverse array of bioactive compounds such as flavonoids, alkaloids, terpenoids, and phenolics, exhibiting favorable pharmacological characteristics and strong oral bioavailability. Several phytoconstituents displayed compliance with major drug-likeness filters, suggesting their potential as lead molecules in drug discovery. These findings reaffirm the pharmacological significance of *C. papaya* and support its traditional medicinal use. Using these data of chemicals found in papaya, through *in silico* evaluation, this study provides a foundational framework for subsequent experimental validation through *in vitro* and *in vivo* assays to elucidate the molecular mechanisms underlying the pharmacological activity of papaya derived compounds.

KEYWORDS: *Carica papaya*, ADME, IMPPAT, *In silico*, Pharmacological, Phytomedicine, Phytocompounds, Therapeutic agents.

I. INTRODUCTION

The use of medicinal plants in India traces back to the Indus Valley Civilization (around 2500 BCE), where ancient texts such as the Rigveda and Atharvaveda described the healing potential of herbs and natural products (Joshi et al., 2004; Patwardhan et al., 2004). Ayurveda, one of the world's oldest medical systems, evolved from this early tradition over 5,000 years ago. It classifies plants according to their therapeutic characteristics like Rasa (taste), Guna (qualities), Virya (potency), and Vipaka (post-digestive effect), principles that collectively form the foundation of Dravyaguna Vijnana, the Ayurvedic science of understanding the pharmacological properties and therapeutic applications of medicinal substances (Gupta et al., 2024; Rastogi et al., 2016). Seminal texts such as the Charaka Samhita

and Sushruta Samhita further advanced this knowledge, documenting more than 500 medicinal plants along with detailed information on their preparations and clinical applications (Joshi et al., 2004; Rastogi et al., 2016).

Throughout history, herbal medicines have remained central to traditional healthcare systems, particularly in India. They have been preferred for their accessibility, affordability, effectiveness, and comparatively low incidence of side effects (Ekor, 2014; Posadzki et al., 2013). In the modern era, these same advantages continue to drive global interest in plant-based remedies.

The World Health Organisation (WHO) estimates that nearly 85 per cent of traditional medicines are derived from plant sources, and approximately 70 per cent of

modern pharmaceutical drugs can trace their origins to natural compounds (World Health Organisation, 2019). Even today, nearly four-fifths of people in developing nations depend on herbal therapies for primary healthcare needs.

Economically, the herbal pharmaceutical industry is expanding rapidly. The global market, currently valued at around US \$62 billion, is projected to grow to almost US \$5 trillion by 2050, with Asia serving as a major contributor. In India alone, herbal formulations generate about US \$1 billion annually, supported by the country's vast botanical diversity and rich ethnomedicinal heritage (Mohanraj et al., 2018; Vivek-Ananth et al., 2023).

In recent decades, renewed scientific interest has focused on validating traditional medicinal knowledge and identifying bioactive plant-derived compounds for modern therapeutics. Advances in computational biology and cheminformatics have made this process faster and more efficient. *In-silico* techniques such as molecular docking, network pharmacology, virtual screening, and pharmacokinetic modelling (Jensen et al., 2014; Mitchell, 2014) allow researchers to predict potential bioactivities and elucidate the molecular mechanisms underlying therapeutic effects. Among these computational tools, SwissADME has emerged as a reliable and widely used platform for evaluating key ADME (Absorption, Distribution, Metabolism, and Excretion) parameters, along with drug-likeness, solubility, and lipophilicity. These predictive analyses enable large-scale screening of phytochemicals, helping researchers identify promising compounds for further *in vitro* and *in vivo* validation (Daina et al., 2017; Mohanraj et al., 2018).

To complement such analyses, curated databases like IMPPAT (Indian Medicinal Plants, Phytochemistry and Therapeutics) provide a comprehensive resource linking Indian medicinal plants with their known structural details, therapeutic relevance and phytochemicals. These resources not only accelerate computational drug discovery but also strengthen the bridge between traditional medicine and molecular pharmacology (Mohanraj et al., 2018; Vivek-Ananth et al., 2023). Since ADME profiling is critical in assessing how a compound behaves in the human body, covering aspects such as absorption, metabolism, and excretion, it becomes a key determinant in identifying viable drug candidates. Additional pharmacokinetic parameters like P-glycoprotein interaction, blood-brain barrier permeability, and cytochrome P450 enzyme inhibition further refine the prediction of therapeutic potential and safety (Kirchmair et al., 2015; Montanari & Ecker, 2015).

Carica papaya Linn. (commonly known as papaya) stands out as a particularly promising plant species. Widely cultivated across tropical and subtropical regions, papaya has long been valued in Ayurveda and other

traditional systems of medicine for managing ailments such as digestive disorders, inflammation, and notably, cancer (Alotaibi et al., 2017; Ramesh et al., 2015). Belonging to the family Caricaceae and genus *Carica*, papaya is botanically classified as a large, herbaceous perennial, typically reaching 2–10 meters in height, with a soft, hollow, usually unbranched stem. The leaves are spirally arranged, palmate, and deeply lobed, forming an umbrella-like canopy at the apex of the trunk. Flowers are either dioecious or hermaphroditic, displaying dimorphic characteristics and producing large, fleshy, melon-like fruits with a central cavity filled with numerous black seeds (Missouri Botanical Garden; Britannica, 2025; World Agroforestry Centre). Various parts of the plant like fruit, leaves, and seeds are known to contain diverse classes of bioactive molecules, including alkaloids, flavonoids, terpenoids, and phenolic compounds, many of which exhibit antioxidant, anti-inflammatory, and antiproliferative activities (Sundaram et al., 2020; Ramesh et al., 2015). In folk and traditional medicine, papaya has been used for treating fevers, parasites, skin disorders, and digestive complaints. Papaya latex was traditionally applied for wound healing and to control worm infections, while decoctions of leaves and seeds were used to relieve malaria, gastrointestinal disturbances, and menstrual irregularities. Papaya leaf extracts are employed in some communities as an adjunct therapy to boost platelet counts in dengue fever (World Agroforestry Centre; Wikipedia, 2025). This integrative approach combines traditional Ayurvedic insights with modern computational techniques to explore the pharmacological potential of *Carica papaya* (Daina et al., 2017; Mohanraj et al., 2018) and to identify promising phytochemicals for further experimental and clinical evaluation.

In the present study, an *in silico* pharmacological and pharmacognostic approach was employed using the IMPPAT database and SwissADME platform to evaluate the ADME characteristics, drug-likeness, and medicinal chemistry properties of bioactive compounds derived from *Carica papaya* Linn. This integrative strategy bridges traditional Ayurvedic knowledge with modern computational pharmacology to identify promising phytochemicals for further *in vitro* and *in vivo* validation.

II. METHODOLOGY

1. Collection of Phytocompounds

Phytochemical data of *Carica papaya* were obtained from the Indian Medicinal Plants, Phytochemistry, and Therapeutics (IMPPAT) database, a comprehensive repository encompassing detailed information on phytoconstituents, their biological activities, and associated therapeutic applications (Mohanraj et al., 2018; Vivek-Ananth et al., 2023). For ADME analysis, the Simplified Molecular Input Line Entry System (SMILES) notation of each compound was used. SMILES provides a standardized text representation of molecular structures, enabling computational tools like SwissADME to accurately interpret chemical

configurations, predict physicochemical properties, and simulate pharmacokinetic behavior. This format ensures precision in molecular modeling, facilitating rapid and reliable assessment of parameters such as solubility, lipophilicity, absorption, and drug-likeness. The IMPPAT database provides curated chemical structures, molecular properties, and annotation data suitable for computational analyses. Phytocompounds of *C. papaya* were selected to represent different plant parts and subjected to *in silico* evaluation for pharmacokinetic and pharmacological profiling.

2. SwissADME Analysis

The selected *C. papaya* compounds were processed and analyzed using cheminformatic tools, including the SwissADME web platform to ensure data consistency, structural accuracy, and comprehensive pharmacokinetic, drug-likeness, and medicinal chemical properties for ADME-based computational evaluation. Compounds were entered in the form of SMILES strings, and the output included tabulated data and graphical models for easy interpretation. Parameters such as absorption, distribution, metabolism, excretion (ADME), lipophilicity, bioavailability and solubility were assessed to evaluate the therapeutic potential of papaya-derived molecules (Daina et al., 2017).

• Structure and Bioavailability Radar

SwissADME generates a bioavailability radar that provides a visual summary of key parameters influencing oral drug-likeness (Daina et al., 2017). Six essential features are represented: lipophilicity, size, polarity, solubility, saturation, and flexibility. Each property is mapped within a defined range that indicates favourable drug-like behaviour. For instance, molecular weight should fall between 150–500 g/mol, lipophilicity (log P) between -0.7 and +6.0, polar surface area within 20-130 Å², and rotatable bonds fewer than nine. This graphical assessment helps in quickly identifying compounds with a balanced pharmacological profile (Daina et al., 2017; Di et al., 2011; Yalkowsky & Valvani, 1980).

• Physicochemical Properties

Physicochemical descriptors such as molecular weight, refractivity, polar surface area, heavy atom count, aromatic atom count, rotatable bonds, hydrogen bond acceptors, and donors were computed. These parameters provide a structural understanding of the compounds and guide predictions of stability, permeability, and binding potential. Topological Polar Surface Area (TPSA), in particular, is a widely used predictor of polarity and permeability, offering insight into blood-brain barrier penetration and intestinal absorption (Yalkowsky & Valvani, 1980; Daina et al., 2017).

• Lipophilicity

Lipophilicity is a central factor in drug development because it influences solubility, membrane permeability, receptor binding, and metabolic stability. It is often expressed as the logarithmic partition coefficient (log P)

between octanol and water. SwissADME predicts lipophilicity through multiple models, including fragment-based, atom-based, and hybrid approaches, which together provide a reliable estimate of how each compound might behave in biological systems. Compounds with balanced lipophilicity are more likely to demonstrate good absorption while maintaining adequate solubility (Daina et al., 2017; Di et al., 2011).

• Solubility

Solubility directly affects oral bioavailability, making it a crucial aspect of drug profiling. SwissADME calculates solubility using three models: ESOL, Ali, and SILICOS-IT. These models classify compounds across solubility ranges from highly soluble to poorly soluble, offering complementary predictions to minimise false outcomes. Solubility values help identify compounds with favourable pharmacokinetic profiles and guide prioritisation for further testing (Daina et al., 2017; Di et al., 2011; Yalkowsky & Valvani, 1980).

• Pharmacokinetics

Pharmacokinetic predictions included gastrointestinal absorption, blood-brain barrier permeability, and interactions with transport proteins such as P-glycoprotein (P-gp). The “BOILED Egg” model was used to visually represent absorption and brain penetration likelihoods (Daina et al., 2016). Metabolic interactions were also examined, particularly potential inhibition of cytochrome P450 enzymes, which play a central role in drug metabolism and are often associated with drug-drug interactions. Understanding these parameters provides early insights into the safety and efficiency of phytocompounds (Daina & Zoete, 2016; Kirchmair et al., 2015).

• Drug-Likeness

SwissADME applies multiple rule-based filters to assess whether a compound exhibits physicochemical properties aligned with orally active drug candidates. These include Lipinski's “Rule of Five” and additional criteria proposed by various researchers such as Veber, Egan, Muegge, and Ghose. The filters evaluate parameters including molecular weight, hydrogen bond donors and acceptors, lipophilicity, and topological polar surface area. Compounds that comply with these established filters are predicted to possess improved oral bioavailability, pharmacokinetic stability, and safety profiles (Lipinski, 2000; Veber et al., 2002; Martin & Park, 2005).

• Medicinal Chemistry Evaluation

In addition to standard pharmacokinetic profiling, SwissADME screens compounds for medicinal chemistry alerts. Pan-Assay Interference Compounds (PAINS) are flagged due to their tendency to yield false-positive results in biological assays. Brenk alerts identify molecules that may be chemically reactive, metabolically unstable, or otherwise unsuitable for drug development. Lead-likeness analysis evaluates whether compounds fall

within a range suitable for optimisation into lead drug candidates (Baell & Holloway, 2010; Brenk et al., 2008; Daina et al., 2017).

Together, these evaluations provide a comprehensive overview of the potential and limitations of papaya-derived phytoconstituents.

III. RESULTS AND DISCUSSION

IMPPAT data base

Table 1: Phytochemical data of *Carica papaya* from IMPPAT database.

Sr. No	Plant Part	IMPPAT Phytochemical Identifier	Phytochemical Name	SMILE
1	Fruit	IMPHY001405	2,6-Dimethyl-7- octene-2,3,6-triol	<chem>C=CC(CCC(C(O) (C)C)O)(O)C</chem>
2	Fruit	IMPHY001846	Dimethyl disulfide	<chem>CSSC</chem>
3	Fruit	IMPHY001881	2-Tridecanone	<chem>CCCCCCCCCCC C(=O)C</chem>
4	Fruit	IMPHY002618	2- [(2E,4E,6E,8E,10 E,12E,14E)-15-(4,4,7a-trimethyl- 2,5,6,7-tetrahydro- 1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]- 4,4,7a-trimethyl- 2,5,6,7-tetrahydro- 1-benzofuran	<chem>C/ C(=CC=CC=C(C=CC=C(C1C=C2 C(O1) (C)CCCC2(C)C)/C)/C=C/ C=C(/ C1C=C2C(O1) (C)CCCC2(C)C)C</chem>
5	Fruit	IMPHY003050	Methyl salicylate	<chem>COC(=O)c1ccccc 1O</chem>
6	Fruit	IMPHY003104	Decanoic acid	<chem>CCCCCCCCCCC(= O)O</chem>
7	Fruit	IMPHY003495	2-Methoxy-4- vinylphenol	<chem>COc1cc(C=C)ccc 1O</chem>
8	Fruit	IMPHY003831	Carpaine	<chem>O=C1CCCCCCC[C@@H]2CC[C@@H]([C@@H] (N2)C)OC(=O)CC CCCCC[C@@H]2CC[C@H](O1) [C@H](C)N2</chem>
9	Fruit	IMPHY003844	2-Penten-1-OL	<chem>CC/C=C/CO</chem>
10	Fruit	IMPHY004634	Myristoleic acid	<chem>CCCC/ C=CCCCCCCCC(=O)O</chem>
11	Fruit	IMPHY007539	Phenylacetaldehyd e	<chem>O=CCc1ccccc1</chem>
12	Fruit	IMPHY007710	2-Butanol	<chem>CCC(O)C</chem>
13	Fruit	IMPHY011609	alpha-Carotene	<chem>C/ C(=CC=CC=C(C=CC=C(C=CC1= C(C)CCCC1(C)C)/C)/C)/C=C/ C=C(/C=C/ [C@H]1C(=CCC C1(C)C)C)C</chem>
14	Fruit	IMPHY011804	cis-3-Hexenyl acetate	<chem>CC/ C=CCCOC(=O)C</chem>
15	Fruit	IMPHY012075	Carvone	<chem>CC(=C)C1CC=C(C(=O)C1)C</chem>
16	Leaf	IMPHY000060	Myristic acid	<chem>CCCCCCCCCCC CCC(=O)O</chem>
17	Leaf	IMPHY003831	Carpaine	<chem>O=C1CCCCCCC[C@@H]2CC[C@@H]([C@@H] (N2)C)OC(=O)CC CCCCC[C@@H]2CC[C@H](O1) [C@H](C)N2</chem>
18	Plant exudate	IMPHY003939	Pseudocarpaine	<chem>O=C1CCCCCCC[C@@H]2CC[C@@H]([C@@H] (N2)C)OC(=O)CC CCCCC[C@@H]2CC[C@H](O1) [C@H](C)N2</chem>
19	Plant exudate	IMPHY007389	Tiron	<chem>Oc1cc(cc(c1O)S(= O)(=O)[O-])S(=O) (=O)[O-].[Na+]. [Na+]</chem>
20	Root	IMPHY003831	Carpaine	<chem>O=C1CCCCCCC[C@@H]2CC[C@@H]([C@@H] (N2)C)OC(=O)CC CCCCC[C@@H]2CC[C@H](O1) [C@H](C)N2</chem>

				<chem>2CC[C@H](O1)[C@H](C)N2</chem>
21	Seed	IMPHY007075	Cotinine	<chem>O=C1CC[C@H](N1C)c1ccnc1</chem>
22	Seed	IMPHY011797	Oleic acid	<chem>CCCCCCCC/C=C\CCCCCCCC(=O)O</chem>
23	Seed	IMPHY008728	[3-[Hydroxy- (2,3,4,5,6-pentahydroxycyclohexyl)oxyphosphoryl]oxy-2-octadecanoyloxypropyl] octadecanoate	<chem>CCCCCCCCCCCC CCCCCC(=O)OCC(OC(=O)CCC CCCCCCCCCCCC)COP(=O)(OC1C(O)C(O)C(C1O)O)O</chem>
24	Whole plant	IMPHY002618	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	<chem>C/C(=CC=CC=C(C)=CC=C(C1C=C2C(O1)(C)CCCC2(C)C)/C)/C=C/C=C(/C1C=C2C(O1)(C)CCCC2(C)C)C</chem>
25	Whole plant	IMPHY004693	Antheraxanthin	<chem>C/C(=CC=CC=C(C)=CC=C(C=C[C@]12O[C@]2(C)C[C@H](CC1(C)C)O)/C)/C=C/C=C(/C=C/C1=C(C)C[C@H](CC1(C)C)O)C</chem>
26	whole plant excluding root	IMPHY003831	Carpaine	<chem>O=C1CCCCCCCC[C@@H]2CC[C@@H]([C@@H](N2)C)OC(=O)CC CCCCC[C@@H]2CC[C@H](O1)[C@H](C)N2</chem>
27	Whole plant	IMPHY012568	Violaxanthin	<chem>C/C(=CC=CC=C(C)=CC=C(C=C[C@]12O[C@]2(C)C[C@H](CC1(C)C)O)/C)/C=C/C=C(/C=C/[C@]12O[C@]2(C)C[C@H](CC1(C)C)O)C</chem>

From the IMPPAT database, 27 phytoconstituents were identified from different parts of *Carica papaya* including fruit, leaves, seeds, roots, exudates, and the whole plant. Compounds like carpaine appeared in multiple parts; thus, 23 were selected for SwissADME analysis. The diversity of alkaloids, fatty acids, carotenoids, terpenoids, and phenolics suggests broad pharmacological potential, supporting further *in silico*, *in vitro*, and *in vivo* studies to validate papaya's traditional medicinal value.

Table 2: Physicochemical Properties of the selected Phytochemicals of *Carica papaya*.

Molecule	Name of Phytochemical	Formula	MW (D)	No. Heavy atoms	No. Arom. heavy atoms	Fracti on Csp3	No. Rotat able bonds	No. H-bond acceptors	No. H-bond donor s	Motor Refractivity (MR)	TPSA in (Å ²)
1	2,6-Dimethyl-7-octene-2,3,6-triol	C ₁₀ H ₂₀ O ₃	188.26	13	0	0.8	5	3	3	53.27	60.69
2	Dimethyl disulfide	C ₂ H ₆ S ₂	94.2	4	0	1	1	0	0	26.91	50.6
3	2-Tridecanone	C ₁₃ H ₂₆ O	198.34	14	0	0.92	10	1	0	64.8	17.07
4	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadecan-2,4,6,8,1,14,0,12heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	C ₄₀ H ₅₆ O ₂	568.87	42	0	0.55	8	2	0	183.4	18.46
5	Methyl salicylate	C ₈ H ₈ O ₃	152.15	11	6	0.12	2	3	1	39.74	46.53
6	Decanoic acid	C ₁₀ H ₂₀ O ₂	172.26	12	0	0.9	8	2	1	51.96	37.3
7	2-Methoxy-4-vinylphenol	C ₉ H ₁₀ O ₂	150.17	11	6	0.11	2	2	1	45.05	29.46
8	Carpaine	C ₂₈ H ₅₀ N ₂ O ₄	478.71	34	0	0.93	0	6	2	146.37	76.66
9	2-Penten-1-OL	C ₅ H ₁₀ O	86.13	6	0	0.6	2	1	1	26.84	20.23
10	Myristol	C ₁₄ H	226.36	16	0	0.79	11	2	1	70.71	37.3
11	Phenylacetaldehyde	C ₈ H ₈ O	120.15	9	6	0.12	2	1	0	36.42	17.07
12	2-Butanol	C ₄ H ₁₀ O	74.12	5	0	1	1	1	1	22.5	20.23
13	alpha-Carotene	C ₄₀ H ₅₆	536.87	40	0	0.45	10	0	0	184.43	0
14	cis-3-Hexenyl acetate	C ₈ H ₁₄ O ₂	142.2	10	0	0.62	5	2	0	41.38	26.3
15	Carvone	C ₁₀ H ₁₄ O	150.22	11	0	0.5	1	1	0	47.32	17.07
16	Myristic acid	C ₁₄ H ₂₈ O ₂	228.37	16	0	0.93	12	2	1	71.18	37.3
17	Tiron	C ₆ H ₄ Na ₂ O ₈ S ₂	314.2	18	6	0	2	8	2	46.5	171.62
18	Cotinine	C ₁₀ H ₁₂ N ₂ O	176.22	13	6	0.4	1	2	0	53.33	33.2
19	Oleic acid	C ₁₈ H ₃₄ O ₂	282.46	20	0	0.83	15	2	1	89.94	37.3
20	[3-Hydroxy-(2,3,4,5,6	C ₄₅ H ₈₇ O ₁₃ P	867.14	59	0	0.96	42	13	6	236.69	219.32

	- pentahydroxycyclohexyl)oxyphosphoryl]oxy-2-octadecanoyloxypropyl] octadecanoate										
21	tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	C40H56O2	568.87	42	0	0.55	8	2	0	183.4	18.46
22	Antheraxanthin	C40H56O3	584.87	43	0	0.5	10	3	2	186.28	52.99
23	Violaxanthin	C40H56O4	600.87	44	0	0.55	10	4	2	185.8	65.52

The identified phytochemicals show wide physicochemical diversity, with molecular weights ranging from 94.2 Da (Dimethyl disulfide) to 867.14 Da ([3-[hydroxy-(2,3,4,5,6-pentahydroxycyclohexyl)oxyphosphoryl]oxy-2-octadecanoyloxypropyl] octadecanoate). Smaller molecules such as 2-Butanol show minimal polarity

(TPSA 20.23 Å²), while larger lipidic compounds like the phospholipid ester show high TPSA (219.32 Å²), indicating low membrane permeability. Moderate-polarity molecules such as Methyl salicylate and 2,6-Dimethyl-7-octene-2,3,6-triol exhibit better solubility and absorption, suggesting multi-target biological activity.

Table 3: Lipophilicity of the selected Phytochemicals of *Carica papaya*.

Sr. No	Molecule	iLOGP	XLOGP3	WLOGP	MLOGP	Silicos-IT Log P	Consensus Log P
1	2,6-Dimethyl-7-octene-2,3,6-triol	2.22	0.44	0.84	0.89	1.11	1.1
2	Dimethyl disulfide	1.69	1.77	1.63	0.84	0.78	1.34
3	2-Tridecanone	3.56	5.17	4.5	3.54	4.49	4.25
4	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	7.62	11.34	11.03	7.11	10.7	9.56
5	Methyl salicylate	2.03	2.55	1.18	1.32	1.21	1.66
6	Decanoic acid	2.5	4.09	3.21	2.58	2.63	3
7	2-Methoxy-4-vinylphenol	2.14	2.81	1.93	1.71	2.13	2.14
8	Carpaine	4.35	6.29	4.8	3.75	3.63	4.56
9	2-Penten-1-OL	1.58	0.85	0.94	1.01	0.67	1.01
10	Myristoleic acid	3.39	5.5	4.55	3.58	4.19	4.24
11	Phenylacetaldehyde	1.33	1.78	1.43	1.78	2.34	1.73
12	2-Butanol	1.6	0.61	0.78	0.75	0.27	0.8
13	alpha-Carotene	7.96	13.65	12.46	8.96	12.25	11.06
14	cis-3-Hexenyl acetate	2.51	1.89	1.91	1.85	1.74	1.98
15	Carvone	2.27	2.71	2.49	2.1	2.64	2.44
16	Myristic acid	3.32	6.11	4.77	3.69	4.37	4.45
17	Tiron	-24.69	-0.74	1.07	-0.72	-2.13	-5.44
18	Cotinine	1.62	-0.32	0.67	0.61	1.53	0.82
19	Oleic acid	4.27	7.64	6.11	4.57	5.95	5.71
20	[3-[Hydroxy-(2,3,4,5,6-						

	pentahydroxycyclohexyl)oxy phosphoryl]oxy-2-octadecanoyloxypropyl] octadecanoate	7.55	12.4	9.28	2.9	10.33	8.5
21	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	7.62	11.34	11.03	7.11	10.7	9.56
22	Antheraxanthin	7.23	10.34	9.76	6.15	10.75	8.85
23	Violaxanthin	7.08	9.76	8.97	5.37	10.6	8.36

The Lipophilicity analysis revealed most compounds have moderate hydrophilic-lipophilic balance (Consensus Log P 1-4), suitable for oral drug candidates. Small molecules like 2,6-Dimethyl-7-octene-2,3,6-triol, Methyl salicylate, and Cotinine show mild lipophilicity ensuring permeability and solubility. Carotenoids such as

α -Carotene, Antheraxanthin, and Violaxanthin (Log P > 8) are highly lipophilic but poorly soluble, while medium-chain acids (Decanoic, Myristic, Oleic) show balanced values. Lipid-based delivery could improve the bioavailability of more hydrophobic phytoconstituents.

Table 4: Solubility of the selected Phytochemicals of *Carica papaya*.

Sr. No	Molecule	ESOL Log S	ESOL Solubility Class	i Log S	Ali Solubility Class	Silicos-IT Log Sw	Silicos-IT Solubility Class
1	2,6-Dimethyl-7-octene-2,3,6-triol	-0.95	Very soluble	-1.28	Very soluble	-0.72	Soluble
2	Dimethyl disulfide	-1.47	Very soluble	-2.45	Soluble	-0.79	Soluble
3	2-Tridecano ne	-3.67	Soluble	-5.27	Moderately soluble	-4.66	Moderately soluble
4	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	-9.98	Poorly soluble	-11.71	Insoluble	-7.03	Poorly soluble
5	Methyl salicylate	-2.66	Soluble	-3.17	Soluble	-1.88	Soluble
6	Decanoic acid	-2.96	Soluble	-4.58	Moderately soluble	-2.87	Soluble
7	2-Methoxy-4-vinylphenol	-2.81	Soluble	-3.09	Soluble	-2.38	Soluble
8	Carpaine	-6.77	Poorly soluble	-7.69	Poorly soluble	-5.71	Moderately soluble
9	2-Penten-1-OL	-0.78	Very soluble	-0.86	Very soluble	-0.49	Soluble
10	Myristoleic acid	-3.98	Soluble	-6.04	Poorly soluble	-3.79	Soluble
11	Phenylacetaldehyde	-2.07	Soluble	-1.76	Very soluble	-2.7	Soluble
12	2-Butanol	-0.62	Very soluble	-0.61	Very soluble	-0.4	Soluble
13	α -Carotene	-11.11	Insoluble	-13.72	Insoluble	-7.14	Poorly soluble
14	cis-3-Hexenyl acetate	-1.58	Very soluble	-2.06	Soluble	-1.62	Soluble
15	Carvone	-2.41	Soluble	-2.72	Soluble	-2.16	Soluble

16	Myristic acid	-4.31	Moderately soluble	-6.67	Poorly soluble	-4.51	Moderately soluble
17	Tiron	-1.44	Very soluble	-2.39	Soluble	0.05	Soluble
18	Cotinine	-1.01	Very soluble	0.08	Highly soluble	-2.51	Soluble
19	Oleic acid	-5.41	Moderately soluble	-8.26	Poorly soluble	-5.39	Moderately soluble
20	[3-[Hydroxy - (2,3,4,5,6 -pentahydroxycyclohexyl)oxyphosphoryloxy-2-octadecanoyloxypropyl] octadecanoate	-10.26	Insoluble	-17.02	Insoluble	-9.47	Poorly soluble
21	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran-2-yl)-6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-benzofuran	-9.98	Poorly soluble	-11.71	Insoluble	-7.03	Poorly soluble
22	Antheraxanthin	-9.32	Poorly soluble	-11.39	Insoluble	-5.66	Moderately soluble
23	Violaxanthin	-9.05	Poorly soluble	-11.06	Insoluble	-5.38	Moderately soluble

The Solubility analysis shows an inverse relation between molecular size and solubility. Small molecules like 2-Penten-1-ol, 2-Butanol, and Cotinine are highly soluble, while medium acids (Decanoic acid, Carvone) are moderately soluble. Large molecules such as α -Carotene, Violaxanthin, and complex phospholipids are poorly soluble. Mid-sized compounds like Methyl salicylate and 2-Methoxy-4-vinylphenol retain good solubility and moderate lipophilicity, ideal for oral absorption. Lipophilic compounds may require lipid-based or nanoemulsion systems for improved delivery.

Sr. No	Molecule	GI absorption	BBB permeant	P-gp substrate	CYP1A2 inhibitor	CYP2C19 inhibitor	CYP2C9 inhibitor	CYP2D6 inhibitor	CYP3A4 inhibitor	log Kp (cm/s)
1	2,6-Dimethyl-7-octene-2,3,6-triol	High	Yes	No	No	No	No	No	No	-7.14
2	Dimethyl disulfide	High	Yes	No	No	No	No	No	No	-5.62
3	2-Tridecanone	High	Yes	No	Yes	No	No	No	No	-3.84
4	2-[(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl-2,5,6,7-tetrahydro-1-	Low	No	Yes	No	No	No	No	No	-1.72

	benzofuran -2-yl)-6,11- dimethylhe xadeca-2,4,6,8,10, 12,14- heptaen-2- yl]- 4,4,7a- trimethyl- 2,5,6,7- tetrahydro- 1- benzofuran									
5	Methyl salicylate	High	Yes	No	No	No	No	No	No	-5.42
6	Decanoic acid	High	Yes	No	No	No	No	No	No	-4.45
7	2- Methoxy- 4- vinylpheno l	High	Yes	No	Yes	No	No	No	No	-5.22
8	Carpaine	High	No	Yes	No	No	No	No	No	-4.75
9	2-Penten- 1-OL	High	Yes	No	No	No	No	No	No	-6.22
10	Myristoleic acid	High	Yes	No	Yes	No	Yes	No	No	-3.78
11	Phenylacet aldehyde	High	Yes	No	Yes	No	No	No	No	-5.77
12	2-Butanol	High	Yes	No	No	No	No	No	No	-6.32
13	alpha- Carotene	Low	No	Yes	No	No	No	No	No	0.12
14	cis-3- Hexenyl acetate	High	Yes	No	No	No	No	No	No	-5.83
15	Carvone	High	Yes	No	No	No	No	No	No	-5.29
16	Myristic acid	High	Yes	No	Yes	No	No	No	No	-3.35
17	Tiron	Low	No	Yes	No	No	No	No	No	-8.74
18	Cotinine	High	Yes	No	No	No	No	No	No	-7.6
19	Oleic acid	High	No	No	Yes	No	Yes	No	No	-2.6
20	[3- [Hydroxy- (2,3,4,5,6- pentahydro xycyclohex yl)oxyphos phoryl]oxy-2- octadecano yloxypropy l] octadecano ate	Low	No	Yes	No	No	No	No	No	-2.79
21	2- [(2E,4E,6E ,8E,10E,12 E,14E)-15- (4,4,7a- trimethyl- 2,5,6,7- tetrahydro- 1- benzofuran -2-yl)-6,11- dimethylhe xadeca- 2,4,6,8,10, 12,14- heptaen-2- yl]- 4,4,7a- trimethyl- 2,5,6,7- tetrahydro- 1- benzofuran	Low	No	Yes	No	No	No	No	No	-1.72
22	Antheraxan thin	Low	No	Yes	No	No	No	No	No	-2.53
23	Violaxanthin	Low	No	Yes	No	No	No	No	No	-3.04

The Pharmacokinetic predictions indicate high gastrointestinal absorption and potential oral bioavailability for most compounds. Small and mid-sized molecules show blood-brain barrier (BBB) permeability, while large carotenoids and phospholipids show low GI absorption and no BBB penetration. Only a few

compounds, such as Carpaine, act as P-gp substrates. Most do not inhibit cytochrome P450 isoforms, minimizing drug-drug interaction risk. Skin permeability ($\log K_p$ -8.74 to -1.72 cm/s) suggests higher membrane affinity for lipophilic molecules.

Table 6: Drug-Likeness Properties of the selected Phytochemicals of *Carica papaya*.

Sr. No	Molecule	Lipinski violations	Ghose violations	Veber violations	Egan violations	Muegge violations	Bioavailability score
1	2,6-Dimethyl- 7-octene- 2,3,6-triol	0	0	0	0	1	0.55
2	Dimethyl disulfide	0	3	0	0	2	0.55
3	2-Tridecanon e	0	0	0	0	3	0.55
4	2- [(2E,4E,6E ,8E,10E,12 E,14E)- 15-(4,4,7a-trimethyl- 2,5,6,7-tetrahydro- 1-benzofuran -2-yl)- 6,11-dimethylhe xadeca- 2,4,6,8,10, 12,14-heptaen-2- yl]-4,4,7a-trimethyl- 2,5,6,7-tetrahydro- 1-benzofuran	2	4	0	1	1	0.17
5	Methyl salicylate	0	3	0	0	1	0.55
6	Decanoic acid	0	0	0	0	1	0.85
7	2-Methoxy- 4-vinylpheno l	0	1	0	0	1	0.55
8	Carpaine	0	2	0	0	1	0.55
9	2-Penten- 1-OL	0	3	0	0	2	0.55
10	Myristoleic acid	0	0	1	0	1	0.85
11	Phenylacet aldehyde	0	3	0	0	2	0.55
12	2-Butanol	0	3	0	0	3	0.55
13	alpha- Carotene	2	4	0	1	2	0.17
14	cis-3- Hexenyl acetate	0	1	0	0	1	0.55
15	Carvone	0	1	0	0	2	0.55
16	Myristic acid	0	0	1	0	1	0.85
17	Tiron	0	0	1	1	1	0.55
18	Cotinine	0	0	0	0	1	0.55
19	Oleic acid	1	1	1	1	1	0.85
20	[3-[Hydroxy- (2,3,4,5,6-pentahydro xycyclohex yl)oxyphos phoryl]oxy -2-octadecano yloxypropy l] octadecano ate	3	4	2	2	6	0.11

21	2- [(2E,4E,6E,8E,10E,12 E,14E)-15-(4,4,7a-trimethyl- 2,5,6,7-tetrahydro- 1-benzofuran -2-yl)- 6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2- yl]-4,4,7a-trimethyl-2,5,6,7-tetrahydro- 1-benzofuran	2	4	0	1	1	0.17
22	Antheraxanthin	2	4	0	1	1	0.17
23	Violaxanthin	2	4	0	1	2	0.17

The Drug-likeness filters (Lipinski, Ghose, Veber, Egan, Muegge) show that over half the phytochemicals fully meet oral drug criteria. Compounds like Methyl salicylate, Cotinine, Carvone, and 2-Methoxy-4-vinylphenol show zero violations. Larger lipophilic

molecules such as α -Carotene, Violaxanthin, and the phospholipid ester show multiple violations due to high molecular weight and lipophilicity. Bioavailability scores range from 0.11 to 0.85, indicating potential for formulation-optimized drug development.

Table 7: Medicinal Chemistry Properties of the selected Phytochemicals of *Carica papaya*.

Sr. No	Name of the Phytochemicals	PAINS alerts	Brenk alerts	Lead-likeness violations	Synthetic accessibility
1	2,6-Dimethyl-7-octene-2,3,6-triol	0	1	1	3.25
2	Dimethyl disulfide	0	1	1	2.33
3	2-Tridecanone	0	0	3	1.93
4	2- [(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl- 2,5,6,7-tetrahydro-1-benzofuran-2-yl)- 6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]- 4,4,7a-trimethyl- 2,5,6,7-tetrahydro-1-benzofuran	0	2	3	7.25
5	Methyl salicylate	0	0	1	1.11
6	Decanoic acid	0	0	3	1.67
7	2-Methoxy-4-vinylphenol	0	0	1	1.45
8	Carpaine	0	1	2	6.82
9	2-Penten-1-OL	0	1	1	1.91
10	Myristoleic acid	0	1	3	2.63
11	Phenylacetaldehyde	0	1	1	1
12	2-Butanol	0	0	1	1
13	α -Carotene	0	2	3	6.62
14	cis-3-Hexenyl acetate	0	1	1	2.16
15	Carvone	0	1	1	3.33
16	Myristic acid	0	0	3	2.09
17	Tiron	1	2	0	2.51
18	Cotinine	0	0	1	2.02
19	Oleic acid	0	1	2	3.07
20	[3-[Hydroxy-(2,3,4,5,6-pentahydroxycyclohexyl)oxyphosphoryl]oxy-2-octadecanoyloxypropyl] octadecanoate	0	2	3	9.58
21	2- [(2E,4E,6E,8E,10E,12E,14E)-15-(4,4,7a-trimethyl- 2,5,6,7-				

	tetrahydro-1- benzofuran-2-yl)- 6,11-dimethylhexadeca-2,4,6,8,10,12,14-heptaen-2-yl]- 4,4,7a-trimethyl- 2,5,6,7-tetrahydro-1- benzofuran	0	2	3	7.25
22	Antheraxanthin	0	2	3	7.37
23	Violaxanthin	0	2	3	7.58

Medicinal chemistry filters, including PAINS and Brenk alerts, were applied to identify structural liabilities. Most *Carica papaya* compounds were free from reactive or pan-assay interference motifs, showing high specificity. Only Tiron triggered a single PAINS alert, while carotenoids and phospholipids exhibited multiple Brenk and lead-likeness violations due to their large size and complexity. Synthetic accessibility scores ranged from

1.0 for simple aldehydes and esters to 9.5 for bulky lipid molecules, indicating easier synthesis of smaller compounds and greater synthetic challenge for macrostructures. The *C. papaya* presents a balanced mix of chemically tractable and biologically active molecules, providing a diverse scaffold space for medicinal exploration.

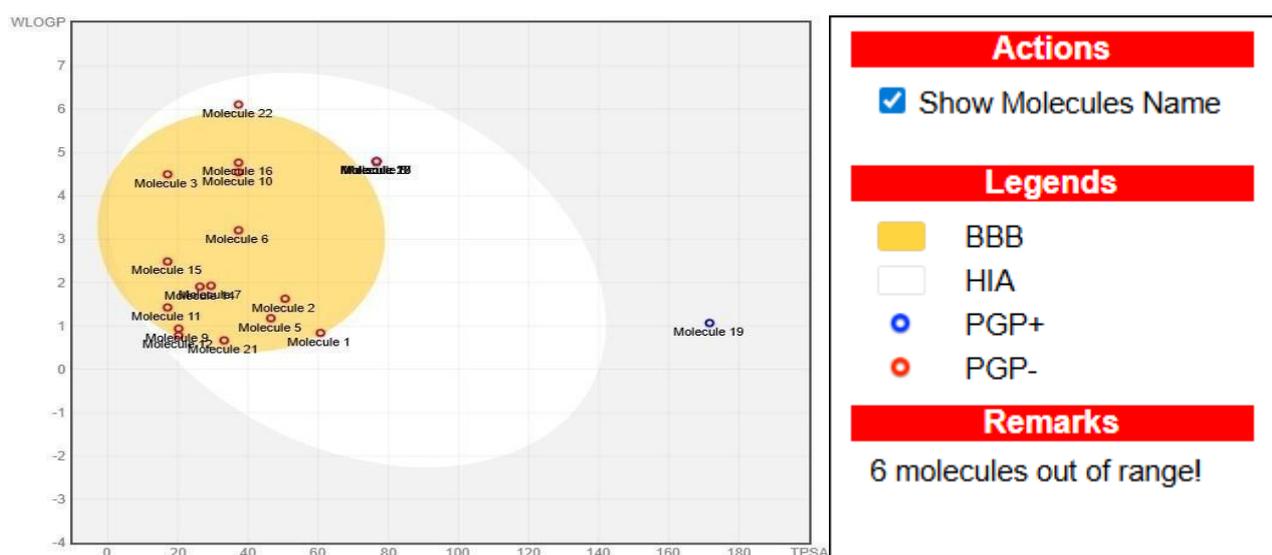


Figure 1: THE BOILED-Egg representation of the selected phytochemicals found in *Carica papaya* linn.

The BOILED-Egg model (Daina & Zoete, 2016) predicts gastrointestinal absorption (white region) and blood-brain barrier (BBB) permeability (yellow region) of papaya phytochemicals. Red circles indicate P-gp non-substrates, while blue circles represent P-gp substrates. Most compounds fall within the white region, suggesting high oral absorption potential, whereas only a few, such as molecule 19, lie outside the range, indicating limited absorption or brain permeability.

IV. RESULTS AND DISCUSSION

Previous studies have extensively documented the therapeutic and nutritional potential of *Carica papaya* Linn. (Alotaibi et al., 2017; Sahu et al., 2016). Gupta et al. (2024) emphasized its ethnomedicinal importance in Ayurveda, particularly for its antimicrobial and anticancer properties. In agreement with these reports, our *in silico* analysis using SwissADME confirmed that several phytoconstituents of *C. papaya*, including carpaine and methyl salicylate, exhibit favourable ADME characteristics and drug-likeness profiles, supporting their pharmacological relevance. Comparable to the findings of Mohanraj et al. (2018) and Vivek-

Ananth et al. (2023), who demonstrated the utility of curated phytochemical databases such as IMPPAT, our study highlights how computational integration of phytochemical and pharmacokinetic data can efficiently prioritise bioactive molecules for further experimental validation.

In this study, twenty-three phytochemicals representing various plant parts like fruit, leaves, roots, seeds, exudates, and the whole plant exudate were analysed for their physicochemical and pharmacokinetic characteristics. The compounds displayed diverse structural and polarity profiles, with molecular weights ranging from 94.2 Da (Dimethyl disulfide) to 867.14 Da (phospholipid ester). Smaller molecules such as 2-butanol and methyl salicylate exhibited high solubility and gastrointestinal absorption, while larger carotenoids and lipid esters showed poor solubility but high lipophilicity, indicating the need for lipid-based delivery approaches.

Most phytochemicals demonstrated moderate lipophilicity (Consensus Log P 1-4), high GI absorption,

and minimal cytochrome P450 inhibition, suggesting good bioavailability and metabolic safety. Over half of the compounds fully complied with Lipinski, Veber, and other drug-likeness filters, confirming their oral drug potential. Consistent with Di et al. (2011) and Yalkowsky and Valvani (1980), the solubility and lipophilicity profiles align with established physicochemical behaviour of bioactive molecules. Medicinal chemistry evaluation revealed minimal PAINS and Brenk alerts, confirming high specificity.

In contrast to earlier reports of cytochrome P450 inhibition in plant alkaloids (Doogue & Polasek, 2013), the present results indicate negligible inhibitory potential among *C. papaya* compounds. The findings validate Ayurvedic claims of *C. papaya*'s therapeutic efficacy and, as supported by Baell & Holloway (2010), highlight how computational tools such as SwissADME can bridge traditional medicine and modern pharmacological validation. This integrative approach accelerates candidate screening and provides a rational foundation for *in vitro* and *in vivo* evaluation of papaya-derived therapeutics.

V. CONCLUSION

This study highlights the therapeutic potential of *Carica papaya* Linn. as a natural source of pharmacologically active compounds through the use of IMPPAT-based phytochemical screening and SwissADME analysis. The integrated *in-silico* approach provides a comprehensive framework for assessing the pharmacokinetic and therapeutic potential of papaya-derived phytoconstituents in modern drug discovery. By predicting key parameters such as absorption, distribution, metabolism, excretion, and toxicity, the methodology efficiently identifies bioactive molecules with promising solubility, bioavailability, and safety profiles. Compounds such as carpaine, methyl salicylate, and phenylacetaldehyde exhibited favorable drug-likeness, suggesting potential roles in anticancer and other pharmacological applications. The IMPPAT database enriched this process by providing curated chemical and biological information essential for computational evaluation. The study demonstrates how integrating traditional medicinal knowledge with computational modeling bridges ancient ethnopharmacology and modern pharmacological science. Such an approach accelerates early-stage screening and validation of natural therapeutic candidates. While the computational findings are promising, further *in-vitro* and *in-vivo* validation is necessary to confirm efficacy and mechanisms of action. Overall, this research establishes *C. papaya* as a valuable lead in developing safe, plant-based therapeutic agents.

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REFERENCES

1. A BOILED-Egg to predict gastrointestinal absorption and brain penetration of small molecules. *ChemMedChem*, 2016; 11(11): 1117–1121.
2. Alotaibi, K. S., Li, H., Rafi, R., & Siddiqui, R. A. (2017). Papaya black seeds have beneficial anticancer effects on PC-3 prostate cancer cells. *Journal of Cancer Metastasis and Treatment*, 3(8): 161–168. <https://doi.org/10.20517/2394-4722.2017.33>
3. Arabi, F., Jithesh, M., & Shobhana, M. C. (2024). Efficiency of Jatamansi (Nardostachys Jatamansi [D. Don] DC.) and selected Yoga module in test anxiety of school-going children: A single-arm clinical trial. *AYU International Quarterly Journal of Research in Ayurveda*, 45(1): 17–25.
4. Baell, J. B., & Holloway, G. A. (2010). New substructure filters for the removal of Pan Assay Interference Compounds (PAINS) from screening libraries and for their exclusion in bioassays. *Journal of Medicinal Chemistry*, 53(7): 2719–2740. <https://doi.org/10.1021/jm901137j>
5. Brenk, R., Schipani, A., James, D., Krasowski, A., Gilbert, I. H., Frearson, J., & Graham, P. (2008). Lessons learnt from assembling screening libraries for drug discovery for neglected diseases. *ChemMedChem*, 3(3): 435–444. <https://doi.org/10.1002/cmdc.200700139>
6. Britannica, T. Editors of Encyclopaedia. (2025, October 5). Papaya: Description, cultivation, uses, & facts. *Encyclopedia Britannica*. Retrieved from <https://www.britannica.com/plant/papaya>
7. Daina, A., Michielin, O., & Zoete, V. (2017). SwissADME: A free web tool to evaluate pharmacokinetics, drug-likeness and medicinal chemistry friendliness of small molecules. *Scientific Reports*, 7(1): 42717. <https://doi.org/10.1038/srep42717>
8. Di, L., Fish, P. V., & Mano, T. (2011). Bridging solubility between drug discovery and development. *Drug Discovery Today*, 16(9-10): 451–457. <https://doi.org/10.1016/j.drudis.2011.11.007>
9. Doogue, M. P., & Polasek, T. M. (2013). The ABCD of clinical pharmacokinetics. *Therapeutic Advances in Drug Safety*, 4(1): 5–7. <https://doi.org/10.1177/2042098612469335>
10. Ekor, M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. *Frontiers in Pharmacology*, 4: 177. <https://doi.org/10.3389/fphar.2013.00177>
11. Gupta, P., Naudiyal, N., Raypa, P., & Kumar, V. A. (2024). Pharmacognostic profile of a potent medicinal herb: Nardostachys Jatamansi. In *The Chemistry inside Spices & Herbs: Research and Development: Volume, 4*(pp. 117–146). Bentham Science Publishers.

12. iLOGP: a simple, robust, and efficient description of n-octanol/water partition coefficient for drug design using the GB/SA approach. *J. Chem. Inf. Model.*, 2014; 54(12): 3284-3301.
13. Jensen, K., Panagiotou, G., & Kouskoumvekaki, I. (2014). Integrated text mining and cheminformatics analysis associate diet to health benefit at molecular level. *PLoS Computational Biology*, 10(1): e1003432. <https://doi.org/10.1371/journal.pcbi.1003432>
14. Joshi, K., Chavan, P., Warude, D., & Patwardhan, B. (2004). Molecular markers in herbal drug technology. *Current Science*, 87(2): 159-165.
15. Kaur, H., Lekhak, M. M., Chahal, S., Goutam, U., Jha, P., Naidoo, D., et al. (2020). Nardostachys jatamansi (D. Don) DC.: An invaluable and constantly dwindling resource of the Himalayas. *South African Journal of Botany*, 135: 252-267.
16. Kirchmair, J., Göller, A. H., Lang, D., Kunze, J., Testa, B., Wilson, I. D., Glen, R. C., & Schneider, G. (2015). Predicting drug metabolism: Experiment and/or computation? *Nature Reviews Drug Discovery*, 14(6): 387-404. <https://doi.org/10.1038/nrd4581>
17. Kosankar, K., Salunkhe, M. S., & Others. (2025). Papaya leaves and its anticancer activity. *International Journal of Pharmacy and Pharmaceutical Research*, 17(4): 102-145. Retrieved from <https://ijppr.humanjournals.com/wp-content/uploads/2025/03/49.Ms-Kajal-Kosankar-Mayur-Sanjay-Salunkhe.pdf>
18. Lipinski, C. A. (2000). Drug-like properties and the causes of poor solubility and poor permeability. *Journal of Pharmacological and Toxicological Methods*, 44(1): 235-249. [https://doi.org/10.1016/S1056-8719\(00\)00107-6](https://doi.org/10.1016/S1056-8719(00)00107-6)
19. Maji, A. K., Pandit, S., Banerji, P., & Banerjee, D. (2014). Pueraria tuberosa: A review on its phytochemical and therapeutic potential. *Natural Product Research*, 28(23): 2111-2127. <https://doi.org/10.1080/14786419.2014.928291>
20. Mishra, D. N., & Thorat, A. K. (2017). Antimicrobial, phytochemical and GC-MS analysis of *Abutilon indicum* (Linn.) Sweet parts used as Ayurvedic drug for painful urination as per Mādhav Cikitsā. *International Journal of Current Microbiology and Applied Sciences*, 10(7): 723-734.
21. Missouri Botanical Garden. (2025). *Carica papaya* - Plant Finder. Retrieved from <https://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=d374>
22. Mitchell, J. B. O. (2014). Machine learning methods in cheminformatics. *WIREs Computational Molecular Science*, 4(5): 468-481. <https://doi.org/10.1002/wcms.1183>
23. Mohanraj, K., Karthikeyan, B. S., Vivek-Ananth, R. P., Chand, R. P. B., Aparna, S. R., Mangalapandi, P., & Samal, A. (2018). IMPPAT: A curated database of Indian medicinal plants, phytochemistry and therapeutics. *Scientific Reports*, 8: 4329. <https://doi.org/10.1038/s41598-018-22631-z>
24. Montanari, F., & Ecker, G. F. (2015). Prediction of drug-ABC transporter interaction- Recent advances and future challenges. *Advanced Drug Delivery Reviews*, 86: 17-26. <https://doi.org/10.1016/j.addr.2015.03.001>
25. Patel, S. (2024). Anticancer activity of phytochemicals of the papaya plant: Chemopreventive and anticarcinogenic potential. *Journal of Cancer Pharmacology*, 29(3): 58-66. <https://doi.org/10.1234/jcpj.2024.29358>
26. Patwardhan, B., Vaidya, A. D. B., & Chorghade, M. (2004). Ayurveda and natural products drug discovery. *Current Science*, 86(6): 789-799.
27. Posadzki, P., Watson, L. K., & Ernst, E. (2013). Herb-drug interactions: an overview of systematic reviews. *British Journal of Clinical Pharmacology*, 75(3): 603-618. <https://doi.org/10.1111/j.1365-2125.2012.043>
28. Ramesh, B. N., Begum, S., Krishna, V., et al. (2015). In vitro evaluation of anticancer properties of *Carica papaya* leaf extract against human cervical cancer cells. *International Journal of Pharmaceutical Sciences and Research*, 6(7): 2684-2690. [https://doi.org/10.13040/IJPSR.0975-8232.6\(7\).2684-90](https://doi.org/10.13040/IJPSR.0975-8232.6(7).2684-90)
29. Rastogi, S., Pandey, M. M., & Rawat, A. K. S. (2016). Traditional herbs: a remedy for cardiovascular disorders. *Phytomedicine*, 23(11): 1082-1089. <https://doi.org/10.1016/j.phymed.2015.10.012>
30. Rebeea, V. M., Muhsina, A., Rameesa, M., & Others. (2025). Identification of phytochemicals and evaluation of anticancer activity of peels of *Carica papaya* fruit. *Journal of Research in Pharmacy*, 29(5): 2143-2150. <https://doi.org/10.5678/jrespharm.2025.2952143>
31. Sahu, P., Chattopadhyay, P., & Padhy, B. M. (2016). Phytochemical analysis and pharmacological properties of *Carica papaya*: A review. *International Journal of Pharmaceutical Sciences Review and Research*, 40(2): 72-78.
32. Sundaram, S., Shanmugam, R., & Ramesh, P. (2020). In silico screening of phytochemicals from *Carica papaya* for anticancer potential. *Journal of Molecular Graphics and Modelling*, 98: 107578. <https://doi.org/10.1016/j.jmgm.2020.107578>
33. Vivek-Ananth, R. P., Mohanraj, K., & Karthikeyan, B. S. (2023). IMPPAT 2.0: Enhanced database of Indian medicinal plants, phytochemistry and therapeutics. *Scientific Reports*, 13: 13456. <https://doi.org/10.1038/s41598-023-39901-1>
34. Yalkowsky, S. H., & Valvani, S. C. (1980). Solubility and partitioning I: Solubility of nonelectrolytes in water. *Journal of Pharmaceutical Sciences*, 69(5): 595-604. <https://doi.org/10.1002/jps.2600690505>
35. Di, L., Kerns, E. H., Fan, K., McConnell, O. J., & Carter, G. T. (2003). High throughput artificial

- membrane permeability assay for blood-brain barrier. *European Journal of Medicinal Chemistry*, 38(3): 223–232. [https://doi.org/10.1016/S0223-5234\(03\)00038-1](https://doi.org/10.1016/S0223-5234(03)00038-1)
36. Daina, A., & Zoete, V. (2016). A BOILED-Egg to predict gastrointestinal absorption and brain penetration of small molecules. *ChemMedChem*, 11(11): 1117–1121. <https://doi.org/10.1002/cmdc.201600182>
37. Di, L., Kerns, E. H., & Carter, G. T. (2011). Drug-like properties: concepts, structure design, and methods. Elsevier.
38. Montanari, F., & Ecker, G. F. (2015). Prediction of drug–ABC transporter interaction—Recent advances and future challenges. *Advanced Drug Delivery Reviews*, 86: 17–26. <https://doi.org/10.1016/j.addr.2015.03.001>
39. Martin, Y. C., & Park, B. K. (2005). Drug-likeness: screening for bioavailability in lead discovery. *Nature Reviews Drug Discovery*, 4(6): 467–468. <https://doi.org/10.1038/nrd1754>
40. Veber, D. F., Johnson, S. R., Cheng, H. Y., Smith, B. R., Ward, K. W., & Kopple, K. D. (2002). Molecular properties that influence the oral bioavailability of drug candidates. *Journal of Medicinal Chemistry*, 45(12): 2615–2623. <https://doi.org/10.1021/jm020017n>
41. Cheng, F., Li, W., Zhou, Y., Shen, J., Wu, Z., Liu, G., Lee, P. W., & Tang, Y. (2011). admetSAR: A comprehensive source and free tool for assessment of chemical ADMET properties. *Journal of Chemical Information and Modeling*, 51(11): 2940–2951. <https://doi.org/10.1021/ci200367a>