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Network Pharmacology Based Identification of Bioactive Compounds from Traditional Medicinal Plants for Treatment of Myocardial Infarction

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***Abstract*-- Myocardial infarction (MI) is a critical cardiovascular disorder arising from sudden impairment of coronary blood supply, resulting in myocardial hypoxia, metabolic imbalance, inflammatory activation, and irreversible tissue damage. The involvement of multiple interconnected molecular events limits the effectiveness of conventional single-target treatment strategies. Traditional medicinal plants contain diverse phytochemicals capable of regulating several biological processes simultaneously, making them suitable candidates for multi-target intervention in MI. Network pharmacology has emerged as a computationally driven approach that integrates phytochemical profiling, target prediction, and pathway analysis to explain complex drug–disease relationships at a systems level. This review discusses the application of network pharmacology in evaluating medicinal plants including Allium sativum, Curcuma longa, Terminaliaarjuna, Panax ginseng, Emblicaofficinalis, Tinosporacordifolia, Withaniasomnifera, Ginkgo biloba, Salvia miltiorrhiza, Vitisvinifera, Sidacordifolia, and Crataegusoxyacantha for myocardial infarction management. Analysis of compound–target networks reveals modulation of key signaling routes such as PI3K/Akt, NF-κB, MAPK, HIF-1, JAK/STAT, calcium homeostasis, and lipid regulatory pathways, contributing to cardiomyocyte survival, vascular protection, and functional recovery. The findings highlight network pharmacology as a reliable systems-engineering tool for rationalizing traditional medicinal plant usage and supporting the development of evidence-based cardioprotective therapies for myocardial infarction.**

***Keywords*-- Myocardial infarction; Network pharmacology; Traditional medicinal plants; Systems biology; Computational pharmacology; Multi-target therapy; Cardioprotection; Signaling pathways; Phytochemicals**

I. INTRODUCTION

A heart attack, or myocardial infarction (MI), ranks as a top worldwide driver of death and disability in ischemic heart disease (IHD), mainly from atherosclerotic plaques accumulating lipids in coronary arteries; their rupture unleashes pro-clotting elements that spark platelet clumping and thrombus buildup, cutting off oxygen and nutrients to heart muscle.

Sustained ischemia beyond 20-40 minutes sparks a chain of anaerobic energy shifts, acid surge, energy collapse, cell wall rupture, swelling, protein leaks, and permanent tissue death via coagulation necrosis, with recovery relying on immune cleanup and collagen scarring that often weakens heart performance.

Network pharmacology is an interdisciplinary and system-oriented approach that integrates pharmacology, bioinformatics, and computational biology to elucidate the complex interactions between bioactive compounds, molecular targets, and disease-associated networks. Unlike the conventional single-target drug discovery model, this approach acknowledges that complex disorders such as myocardial infarction arise from dysregulation of multiple interconnected biological pathways. Network pharmacology is particularly suitable for evaluating traditional medicinal plants, as their diverse phytoconstituents can simultaneously modulate multiple targets involved in oxidative stress, inflammation, endothelial dysfunction, apoptosis, and cardiac remodeling. By constructing compound–target and protein–protein interaction networks and performing pathway enrichment analyses, this method identifies key regulatory nodes and signaling pathways, including PI3K/Akt, MAPK, NF-κB, HIF-1, JAK/STAT, and calcium signaling. Consequently, network pharmacology provides a scientific and systematic framework for understanding the multi-mechanistic cardioprotective effects of medicinal plants and supports their rational development as complementary or alternative therapeutic strategies for myocardial infarction.

Medicinal plants have been a vital source of both curative and preventive medical therapy preparations for human beings, which also has been used for the extraction of important bioactive compounds .It is estimated that almost 80% of the world's total population, regularly, depends on traditional medicine and products for its healthcare needs especially in third world countries. Many sick people in the developing regions combine the conventional medicine with traditional medicine

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Role: Vital sources for treating and preventing disease ; integral to community healthcare.

Prevalence: Nearly 80% of people globally rely on traditional medicine , especially in developing countries. Regional reliance high in Sub-Saharan Africa where conventional access is limited.

Challenges: Need for preservation, scientific validation, and integration into modern healthcare.

Opportunity: Integrate validation indigenous knowledge to improve affordability, accessibility, and cultural relevance.

II. Literature Review

Why Network Pharmacology is Fit for MI-TMP Studies ?

Given the multi-process nature of MI, a single-target drug may fall short. Network pharmacology allows:

- Identification of bioactive compounds from plants that may modulate multiple targets relevant to MI.
- Elucidation of molecular mechanisms and signalling pathways through which the compounds may act.
- Prioritisation of compounds and targets for further experimental validation and drug-development potential.

For instance, recent studies show network pharmacology analyses of plant extracts against myocardial ischaemia/reperfusion injury (MI/RI) identifying multiple pathways.

Literature Review Of Network Pharmacology

1. Study on Salvia miltiorrhiza Dalbergiaodorifera Coupled-Herb (SMDOCH)

In one landmark study, Li et al. (2019) used network pharmacology to elucidate mechanisms of SMDOCH in coronary heart disease (CHD) including MI. They screened 104 bioactive components and 58 overlapping targets between the herb and CHD. Enrichment analysis showed 10 significant signalling pathways grouped into three functional modules: vascular endothelial function regulation, inflammatory response, and lipid metabolism. This demonstrates how network pharmacology can reveal key mechanistic modules for TMP in MI/CHD.

2. Study of Total Salvianolic Acid Injection on MI/RI

Li et al. (2023) conducted a network pharmacology-based analysis of total salvianolic acid injection (TSI) for myocardial ischemia-reperfusion injury (MI/RI). They identified 90 targets and 7 critical signalling pathways including PI3K signalling, JAK-STAT, Calcium signalling, HIF-1, and others. They further reviewed literature supporting the roles of these pathways in MI/RI.

3. More Recent Integrative Network Pharmacology Work

Huang et al. (2023) applied integrated network pharmacology and in vivo studies on Salvia miltiorrhiza in MI, identifying key targets/mechanisms. A very recent review (Das et al. 2025) summarises network pharmacology approaches to MI, noting multi-target anti-inflammatory effects of natural products such as salvianolic acids and resveratrol via PI3K/Akt, NF-κB, HIF-1 pathways.

Bioactive Compounds & Key Targets

Some of the common bioactive plant compounds identified in network pharmacology studies for MI/MI/RI include salvianolic acids (from S. miltiorrhiza), tanshinones, flavonoids (e.g., quercetin, kaempferol), phenolic acids, etc. For example, in the TSI study key targets included SRC, CTNNB3, PIK3CA, AKT1, RELA, EGFR, FYN, ITGB8, MAPK1, NFKB2.

Major Pathways Identified

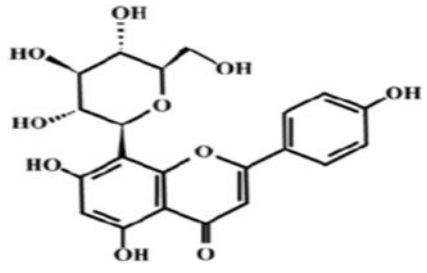
Across the studies, frequently enriched pathways include:

- PI3K/Akt signalling – key in cell survival, anti-apoptosis.
- NF-κB signalling – central to inflammation.
- HIF-1 signalling – relevant to hypoxia and re-oxygenation injury.
- JAK/STAT pathway – immune/inflammatory modulation.
- Calcium signalling and endothelial function regulation.
- Lipid metabolism pathways, vascular endothelial regulation

Literature Review Of Traditional Medicinal Plants:

1. Crategus Oxycantha:

Crataegus is a medicinal plant traditionally used for cardiovascular disorders, particularly ischemic heart disease. Its cardioprotective effects are primarily attributed to flavonoids (vitexin, hyperoside) and oligomericprocyanidins.



Vitexin

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Methods Used:

A systematic review of experimental studies and controlled clinical trials was conducted to evaluate the cardiovascular effects of Crataegus in heart failure, hypertension, and lipid disorders.

Results:

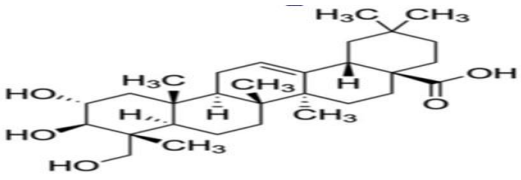
Studies demonstrate that Crataegus extracts improve myocardial contractility, enhance coronary blood flow, reduce oxidative stress, modulate lipid profiles, and improve cardiac function.

Conclusion:

Crataegus exhibits strong cardioprotective potential and serves as a valuable natural agent for supporting cardiovascular health.

2. Terminalia Arjuna:

Terminaliaarjuna is a traditional medicinal tree widely used for cardiovascular disorders. Its bark contains key bioactive compounds including arjunolic acid, along with flavonoids, tannins, and triterpenoids, which collectively contribute to its cardiotonic and antioxidant effects.



Methods Used:

A review of preclinical and clinical studies was conducted to evaluate the cardiovascular and myocardial protective effects of Terminaliaarjuna.

Results:

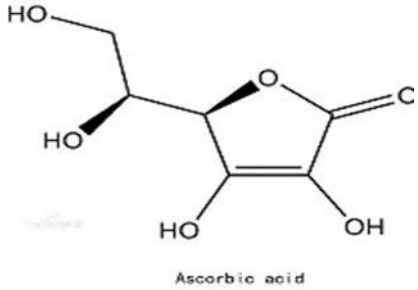
Evidence shows that T. arjuna enhances myocardial contractility, reduces oxidative stress, improves lipid metabolism, and protects cardiac tissue from ischemic damage.

Conclusion:

Terminaliaarjuna, particularly due to arjunolic acid, demonstrates strong cardioprotective potential and plays a beneficial role in maintaining and improving heart function.

3. Emblica Officinalis:

Emblicaofficinalis is a medicinal fruit rich in ascorbic acid (vitamin C), emblicanin A and B, and flavonoids, known for its antioxidant and cardioprotective properties.



Methods Used:

A systematic evaluation of in vitro, animal, and clinical studies was conducted to analyze its cardiovascular and antioxidant effects.

Results:

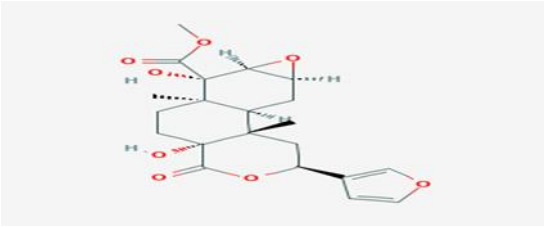
Studies reveal that E. officinalis reduces oxidative stress, improves endothelial function, lowers lipid levels, and protects myocardial tissue against ischemic injury.

Conclusion:

Emblicaofficinalis demonstrates excellent cardioprotective activity and is beneficial in promoting cardiovascular health.

4. Tinospora Cordifolia:

Tinosporacordifolia is a medicinal vine traditionally used for cardioprotection and immune support. Its therapeutic effects are mainly attributed to tinosporin, along with other bioactive compounds.



Methods Used:

A comprehensive review of phytochemical and pharmacological studies was carried out to assess its antioxidant and cardioprotective properties.

Results:

Findings indicate that T. cordifolia improves myocardial function, reduces oxidative damage, regulates lipid levels, and protects cardiac tissue in experimental models.

Conclusion:

Tinosporacordifolia shows promising cardioprotective potential and contributes positively to overall cardiovascular health.

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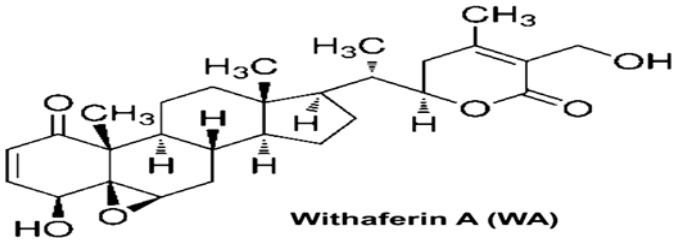
5. Withania Somnifera:

With aniasomnifera is a Rasayana herb containing with aferin and other with anolides, which provide antioxidant, anti-inflammatory, and cardioprotective effects.



Withaferin A (WA)

Methods Used:

A comprehensive review of experimental and clinical studies was conducted to evaluate its pharmacological and cardiovascular benefits.

Results:

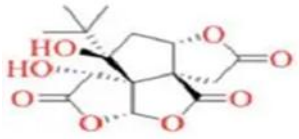
Studies demonstrate that W. somnifera exhibits antioxidant, anti-inflammatory, hypolipidemic, immunomodulatory, and cardioprotective activities.

Conclusion:

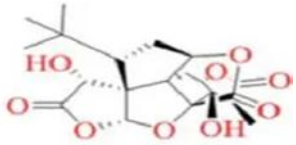
Withaniasomnifera, through withaferin, plays a positive role in cardiovascular protection and supports overall cardiac health.

6. Gingko Biloba:

Ginkgo biloba contains key bioactive compounds bilobalides and ginkgolides, which contribute to its antioxidant, anti-apoptotic, and cardioprotective effects in myocardial injury.



Bilobalide



Ginkgolide-A

Methods Used:

An aged rat model of acute myocardial infarction and in vitro cardiomyocyte assays were used to evaluate the cardioprotective effects of standardized Ginkgo biloba extract.

Results:

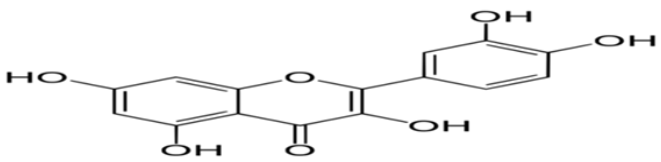
Treatment significantly reduced infarct size and cardiomyocyte apoptosis and activated the AKT/GSK3β/β-catenin signaling pathway, enhancing cardiomyocyte survival.

Conclusion:

Ginkgo biloba, through bilobalides and ginkgolides, exhibits strong cardioprotective activity and effectively supports myocardial protection.

7. Sida Clodifloria:

Sidacordifolia is a traditional medicinal plant containing key bioactive compounds such as quercetin, along with alkaloids, flavonoids, steroids, and fatty acids, which contribute to its antioxidant and cardioprotective properties**.**



Quercetin molecular structure

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Methods Used:

A comprehensive literature review was carried out using published ethnomedicinal, phytochemical, and pharmacological studies to evaluate the therapeutic potential of Sidacordifolia.

Results:

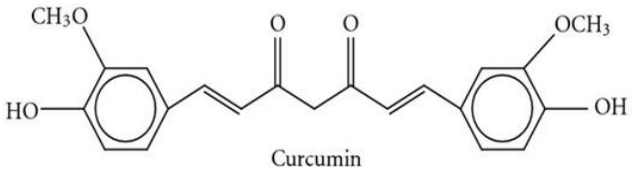
Studies report that Sidacordifolia exhibits antioxidant, anti-inflammatory, cardioprotective, analgesic, and metabolic regulatory activities in experimental models.

Conclusion:

Sidacordifolia, supported by quercetin and other bioactive constituents, demonstrates significant therapeutic and cardioprotective potential.

8. Curcuma Longa:

Curcumin, the principal bioactive compound in turmeric, is known for its antioxidant, anti-inflammatory, and anti-apoptotic properties that contribute to cardioprotection, particularly against myocardial ischemia-reperfusion injury.



Curcumin

Methods Used:

A systematic review and meta-analysis of preclinical animal studies and clinical trials was conducted by searching eight electronic databases to assess the effects of curcumin on myocardial infarction size and cardiac function outcomes.

Results:

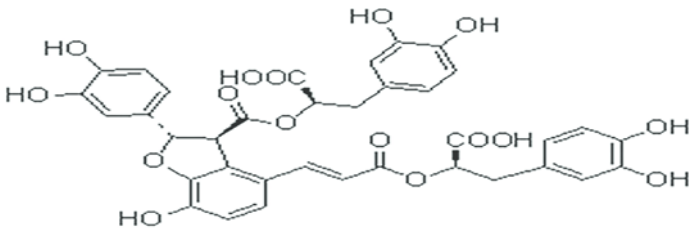
The meta-analysis demonstrated that curcumin significantly reduced myocardial infarction size and improved cardiac function parameters in animal models, and clinical evidence suggested reduced incidence of cardiac dysfunction and major adverse cardiovascular events.

Conclusion:

Curcumin exhibits strong cardioprotective effects through reduction of myocardial injury and enhancement of cardiac outcomes, supporting its potential as a beneficial therapeutic agent.

9. Salvia Miltiorrhiza:

Salvia miltiorrhiza is a traditional cardiovascular medicinal herb whose cardioprotective effects are mainly attributed to salvianolic acid B and tanshinones, which support myocardial protection and vascular function.



Salvianolic acid B

Methods Used:

Network pharmacology analysis combined with in vitro and in vivo experiments was used to identify active compounds, molecular targets, and cardioprotective mechanisms in myocardial infarction.

Results:

The study demonstrated improved cardiac function, reduced myocardial fibrosis, and enhanced endothelial protection through activation of cardioprotectivesignaling pathways.

Conclusion:

Salvia miltiorrhiza, driven by salvianolic acid B, exhibits strong cardioprotective potential and supports myocardial recovery.

10. Allium Sativa:

Allicin is the principal bioactive sulfur compound of garlic with established antioxidant, anti-inflammatory, and cardioprotective relevance in cardiovascular disorders.

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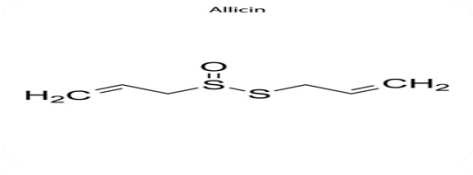


Methods Used:

Evidence was compiled from in vitro, in vivo, and clinical studies evaluating allicin-mediated cardioprotection.

Results:

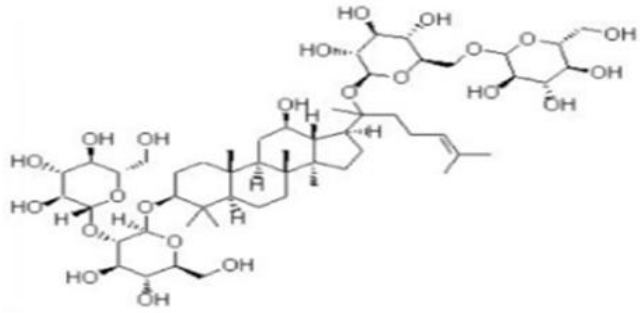
Allicin reduced oxidative stress, inflammation, myocardial injury, and improved vascular and lipid homeostasis.

Conclusion:

Allicin exhibits strong cardioprotective potential and supports cardiovascular health.

11. Panax Ginseng:

Panax ginseng is a medicinal herb whose cardioprotective activity is mainly attributed to ginsenosides, particularly ginsenoside Rb1, which support myocardial and vascular function.



ginsenoside Rb1

Methods Used:

A comprehensive literature review was conducted using electronic databases and bioinformatics tools to collate in vitro and in vivo evidence on the cardiovascular protective mechanisms of Panax ginseng and its active ingredients.

Results:

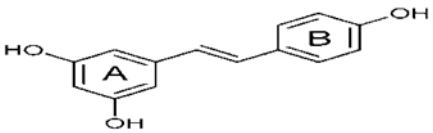
Ginsenosides reduced oxidative stress, inflammation, myocardial injury, and improved cardiac energy metabolism.

Conclusion:

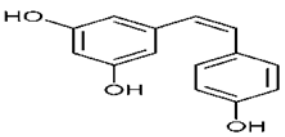
Panax ginseng, through ginsenoside Rb1 and related compounds, demonstrates strong cardioprotective potential by improving myocardial energy metabolism and supporting cardiac resilience.

12. Vitis Vinifera:

Grape leaves (Vitisvinifera) contain key bioactive compounds such as resveratrol, flavonoids, catechins, and tannins, which contribute to antioxidant, anti-inflammatory, lipid-lowering, and vasodilatory effects relevant to cardiovascular health.



Trans (E)
Resveratrol



Cis (Z)
Resveratrol

Methods Used:

A comprehensive review of traditional and scientific literature was conducted to compile evidence from in vitro, in vivo, and clinical studies on the cardiovascular benefits of grape leaves and their phytochemicals.

Results:

The phytochemicals in grape leaves help regulate oxidative stress, improve lipid metabolism, enhance endothelial function, and modulate inflammation, collectively supporting cardioprotection.

Conclusion:

Grape leaves demonstrate strong cardioprotective potential and support overall cardiovascular health through multiple beneficial mechanisms.

S.NO	PLANT	ACTIVE COMPOUNDS	MECHANISM/ PATHWAYS	MARKETED FORMULATIONS
1.	Allium sativa	Allicin,Sallylcysteine	Antiplatelet, antioxidant; NF-κB, COX-2, IL1B	Garlic Oil Capsules[Himalaya Lasuna] Kyolic®
2.	Curcuma longa	Curcumin	Antioxidant, anti-inflammatory; MAPK, TNF, Nrf2	Curcumin C3 Complex,Turmix Capsules [Charak] Curcuma Plus Tablets
3.	Terminaliaarjuna	Arjunolic acid, Triterpenoids	Antioxidant, cardioprotective, improves LV function; TNF, IL6, AKT1, MAPK1	Arjuna Capsules[Organic India], Arjunarishta,Carditone[Himalaya]
4.	Panax ginseng	Ginsenosides (Rb1, Rg1)	Enhances NO production, reduces oxidative stress; AMPK, eNOS, TNF	Ginseng Capsules[Korean Red Ginseng],Gericaps [Ranbaxy]
5.	Emblicaofficinalis	Ascorbic acid, Gallic acid, Ellagic acid	Antioxidant, prevents LDL oxidation; Nrf2/HO-1, NF-κB	Amla Capsules[Himalaya],Triphala Tablets ,Chyawanprash
6.	Tinosporacordifolia	Tinosporin, Berberine, Magnoflorine	Reduces cardiac damage; PI3K-Akt, NF-κB, TNF	GiloyGhanvati[Patanjali],Guduchi Tablets[Himalaya]
7.	Withaniasomnifera	Withaferin A, Withanolides	Stabilizes mitochondria, anti-apoptotic; Caspase-3, HSP70, MAPK	Ashwagandha Capsules[Himalaya],Sensoril®,KSM-66 Ashwagandha
8.	Gingko biloba	Ginkgolides, Bilobalide	Improves blood flow, anti-apoptotic; PI3K-Akt, Nrf2,	Ginkgo Biloba Tablets[Himalaya Mentat],Tanakan®,Tebonin®
9.	Salvia miltiorrhza	Tanshinones, Salvianolic acid B	Anti-inflammatory, improves microcirculation; PI3K-Akt, NF-κB, MAPK	Danshen Dripping Pills,CompoundDanshen Tablets
10.	Vitisvinefra	Resveratrol, Quercetin	Improves endothelial function; SIRT1, PI3K-Akt, AMPK	Resveratrol Supplements[Resveratol Plus],Grape seed extrsct capsules
11.	Sidaclodiforia	Q, Sterols	Enhances cardiac output, antioxidant; Adrenergic, ROS scavenging	BalaTaila[Ayurvedic oil],Bala Capsules[Herbal Hills]
12.	Crategusoxycantha	Vitexin, Hyperoside	Coronary vasodilator, antioxidant; HIF1A, VEGF, NOS3	Hawthorn Extract WS-1442 capsules,Crataegus heart Drops

III. CONCLUSION

Traditional medicinal plants play a vital role in myocardial infarction by exerting antioxidant, anti-inflammatory, and anti-apoptotic effects, scavenging reactive oxygen species, enhancing enzymes like SOD and catalase, suppressing NF-κB, TNF-α, and IL-6, and regulating PI3K/Akt, MAPK, and mitochondrial pathways to preserve cardiomyocyte viability. They also improve endothelial function, coronary vasodilation, lipid metabolism, and prevent **adverse**remodeling, collectively reducing infarct size, enhancing contractility, and supporting post-ischemic recovery. Among the plants reviewed, Terminaliaarjuna shows the strongest cardioprotective potential, followed by Ginkgo biloba and Salvia miltiorrhiza, through antioxidant, anti-inflammatory, anti-apoptotic, and angiogenic mechanisms.

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