**RAPHANUS SATIVUS** - A REVIEW OF ITS TRADITIONAL USES, PHYTOCHEMISTRY, AND PHARMACOLOGY

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**ABSTRACT**

*Raphanus sativus* (*R. sativus*) is a widely used vegetable belonging to the family *Brassicaceae*, generally grown as annual or biennial plants, with a taproot which is much enlarged when it is cultivated. In Yemenite folk medicines, *R. sativus* juice is used in eliminating kidney stones. Few people, specifically in the Middle East, prefer to drink its juice in pursuit of certain health benefits. In Unani, Greeko-Arab, and Indian folk medicine, it is used as a home remedy for the treatment of many diseases such as jaundice, gallstone, liver diseases, rectal disorder, indigestion, and other gastric pains. This article has reviewed the information available on *R. sativus* ethnopharmacology, geographical distribution, chemical composition, and pharmacological uses. The information on botanical description, distribution, traditional uses, chemical composition, bioactive components, and therapeutic investigations was gathered from a comprehensive literature search of electronic databases such as Science Direct, PubMed, Web of Science, Wiley, ACS, Springer, Google Scholar, and SCOPUS until 2020 for publications. An elaborative study has been done on botanical characterization, traditional uses, chemical composition, and various pharmacological or therapeutic publications. Mainly this plant is fully loaded with polyphenolic compounds which exert a promising antioxidant property. This plant possesses various therapeutic benefits such as anti-inflammatory, anti-microbial, anti-tumorigenic, anti-cancer, anti-diabetic, and anti-nephroprotective activity. The comprehensive literature analysis shows that a wide range of populations has utilized various parts of *R. sativus* around the globe. The above information shows that the plant holds a variety of hidden and unknown potentials which can be studied extensively for its phytoconstituents and therapeutic outcomes. However, while searching through the literature available, it was observed that there is a lack of information on its phytochemical profiling and its corresponding pharmacological benefits. It is believed that this review will help lay the groundwork for encouraging pharmacological and pharmaceutical studies.

**Keywords:** Raphanus sativus, Ethnopharmacological, Radish.

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**INTRODUCTION**

Plants have been used in therapy since the ancient ages, and they can be the solution to various diseases and among them *Raphanus sativus*. It is one of the most important vegetables which has enormous activities. *R. sativus* belong from the *Brassicaceae* family which is generally grown as annual or biennial plants, with a taproot which is much enlarged when it is cultivated [1]. *R. sativus* sprouts contain polar and non-polar compounds that could possibly possess antimicrobial activity [2]. Crude juice of the *R. sativus* inhibited the growth of *Escherichia coli*, *Pseudomonas pyocyaneus*, *Salmonella typhi*, and *Bacillus subtilis in vitro* [3]. It has been also found that *R. sativus* helps to fight cancer as it contain sulforaphane having quinone reductase activity which inhibits the growth of colon cancer cells [4]. Saponin-also found in cruciferous plants was reported to cause some necrotic cell death [5]. *R. sativus* has also significant antioxidant activity and anthocyanin named cyanidin glycosides has an o-dihydroxy structure, and cyanidin glycosides have a high antioxidant capacity [6]. Research shows that *R. sativus* has a big impact on the kidney and ethanolic and water extract of *R. sativus* have a nephroprotective effect against rifampicin [7]. *R. sativus* crude extract when tested on the blood pressure and heart rate of normotensive rats under anesthesia, exhibited a dose-dependent inhibition, which is in line with its traditional use in hypertension [8]. The extract caused a dose-dependent (0.13 mg/kg) fall in the blood pressure and heart rate of rats that was mediated through an atropine-sensitive pathway [9].

**TAXONOMIC CHARACTERISTICS [10]**

- Kingdom: Plantae-plantes, Planta, Vegetal, plants
- Subkingdom: Viridiplantae-Green plants
- Infrakingdom: Streptophyta-land plants
- Division -Tracheophyta-vascular plants, tracheophytes
- Superdivision-Embryophyta
- Subdivision-Spermatophytina-spermatophytes
- Class-Magnoliopsida
- Order-Brassicales
- Family-Brassicaceae
- Genus-Raphanus L.
- Species-Raphanus sativus L.

**BOTANICAL CHARACTERIZATION**

*R. sativus* is having few morphological characteristics which may help in identifying the plant/fruit. *R. sativus* (Radish) belongs to the family *Brassicaceae*. Radish plants grow annually or biannually, specifically in the season of winter. It is generally grown from March to August in the hills and is available all over the world. The external features of radish plants include variation in leaves type, leaves arrangement, flower petal color, flower symmetry, and fruit type. It is observed that the flowers of the *R. sativus* used to be symmetrical in nature. The color of the *R. sativus* flower petals are pink, white, and yellow. There are two types of leaves. One is called a compound leaf (made up of two or more discrete leaflets) and another is called a simple leaf (lobed or un-lobed but not separated into leaflets). The leaf arrangement used to be an alternative arrangement that is there is one leaf per node along the stem. The edge of the leaf blade has lobes and a teeth kind of structure. The fruit of *R. sativus* used to be dry with the range of the weight 10–250 mm but does not split into pieces when ripe. The farmers usually cultivate the radish in the season of winter as it needs a clear sunlight and low temperature for better growth [11].
TRADITIONAL USES ACCORDING TO LOCALITY BASIS OR COUNTRY BASIS

R. sativus has multi-purpose uses in terms of food or medicinal properties. As for being an edible plant, R. sativus leaf and fruit are generally cooked or sometimes eaten raw. It is having astringent and diuretic properties that’s why used traditionally to increase bile flow. R. sativus juice is an old home remedy for cough, rheumatic arthritis, and gallbladder stones [12]. Usually, people eat raw radishes mainly in salad, but it is also seen in many European dishes. Few people, specifically in the Middle East, prefer to drink its juice in pursuit of certain health benefits. In Unami, Greeko-Arab, and Indian folk medicine, R. sativus is used as a home remedy for the treatment of many diseases such as jaundice, gallstone, liver diseases, rectal disorder, indigestion, and other gastric pains. The leaves which generally have been discarded are containing 10 times more vitamin C than roots thus containing more anti-oxidant properties. In Yemenite folk medicines, R. sativus juice is used in eliminating kidney stones [13]. The leaves, and roots can be used in asthma, chest tightness, and even in the infection by intestinal parasites. The root is antiscorbutic, antikasmodic, astringent, cholagogue and digestive. The plant contains naphthoquin, which is antibacterial and antifungal in nature, thus inhibiting the growth of Staphylococcus aureus, E. coli, streptococci, and Pneumococci. The plant also shows anti-tumor activity.

Eating R. sativus also enhances your body’s natural adiponecin (a protein hormone) production. Higher levels of this hormone can help to protect against insulin resistance. R. sativus is rich in antioxidants and minerals such as calcium and potassium. Together, these nutrients help to lower high blood pressure and reduce your risk for heart disease. R. sativus is also a great source of natural nitrates that improve blood flow.

R. sativus contains an ample amount of glucosinolates-sulfur compounds which show a protective effect toward the cells from genetic mutations that cause cancer and also prevent the growth of tumor cells [13,14].

PHYTOCHEMISTRY [15]

R. sativus is containing a lot of phytoconstituents that show a wide range of biological activities. Various parts of it consisting various phytochemicals. The predominant phytoconstituents are shown in Fig. 1.

PHARMACOLOGICAL ACTIVITIES OF R. SATIVUS PLANT

Anti-oxidant activity

R. sativus plant is potential as antibacterial, antiinflammation, and also as anti-oxidant because of its sapoim, flavonoid, polyphenol, glycoside, essential oil, vitamin A, and vitamin C content [11]. The presence of antioxidants is needed to prevent the oxidation process and maintain the quality of food products from rancidity, discoloration, and other physical spoilage [12]. R. sativus extract had 10.5% (w/v) glucosolate glucoraphasatin activity and 154.5% anti-radical power by the presence of 0.098 flavonoid and 24.32 µg/mL phenolic compound [13]. Previous reports confirmed that antioxidants and tyrosinase from many vegetables and fruits has been widely studied. This study indicated that the antioxidant and antityrosinase capacity of these vegetables in Thailand, including white R. sativus, garlic and ginger due to the presence of radical scavenging, phenolic flavonoids and antityrosinase compounds [15].

Antioxidant activity is generally based on the number and location of hydroxyl groups present as well as the presence of a 2–3 double bond and 4-oxo function [16]. Flavonoids inhibit enzymes such as prostaglandin synthase, lipooxygenase, and cyclooxygenase, closely related to tumorogenesis, and may induce detoxifying enzymes such as glutathione S-transferase [17]. Anthocyanin is named cyanidin glycosides having o-dihydroxy structure, cyanidin glycosides have a high antioxidant capacity [18].

Anti-inflammatory Activity

R. sativus crude extract when tested on the blood pressure and heart rate of normotensive rats under anesthia, exhibited a dose-dependent inhibition, which is in line with its traditional use in hypertension [19]. The hypotensive effect of the plant extract was briefly similar to that of acetycholine or carbachol [20]. Acetycholine is known to cause a fall in blood pressure by activation of the muscarinic receptors located on the endothelium of blood vessels [21]. The plant extract tested positive for the presence of different classes of compounds such as saponins, flavonoids, tannins, phenols, and alkaloids [6]. Some of these classes of compounds, such as saponins were responsible for cholineric receptor-mediated cardiovascular inhibitory activities [22]. The extract caused a dose-dependent (0.13 mg/kg) fall in the Blood Pressure and Heart Rate of rats that was mediated through an atropine-sensitive pathway [20]. The study showed that the cardiovascular inhibitory effects of the plant are mediated through the activation of muscarinic receptors, thus possibly justifying its use in Hypertension [23]. Hypertension in SHR was suppressed after 4 weeks of feeding with R. sativus leaf powder. We also confirmed the inhibitory activity of R. sativus leaf powder for ACE measured in a previous study [24]. Ethanolic extracts of R. sativus leaves is identified with Sinaic acid which is considered as the main ingredient for anti-inflammatory effects. The addition of active fraction markedly inhibited LPS-stimulated production of inflammatory mediators by suppressing p38 Mitogen-activated protein kinase and nuclear factor-xB activation [25].

Anti-microbial activity

Plants have been used in therapy since ancient ages, and they can be the solution to all previously mentioned problems using the different anticancer and antimicrobial products found naturally in plants. Many plants are known to exhibit antioxidant activity, and consuming them reduces the risk of free radicals. Furthermore, plants that possess anticancer activity can be a safer replacement for chemotherapy with fewer side effects [9]. R. sativus sprouts contain polar and non-polar compounds that could possibly possess antimicrobial and anticancer activity [26]. Crude juice of the R. sativus inhibited the growth of E. coli, P. pyocyaneus, S. typhi, and S. subtilis in vitro. This common plant may be an important source of antimicrobial substances [27]. The cyanine-rich peptides (Rs-AFP1 and Rs-AFP2) isolated from R. sativus showed substantial antifungal activity against several fungal species with minimal inhibitory concentration of 30–60 µg/mL. Both Rs-AFPs are among the most potent antifungal proteins characterized. Moreover, their antibiotic activity shows a high degree of specificity to filamentous fungi [28].

The active region of the antifungal protein appears to involve β-strands 2 and 3 in combination with the loop connecting these strands [29]. Two purified antifungal proteins RAP-1 and RAP-2 isolated from Korean R. sativus seeds (R. sativus) exhibited growth-inhibitory activities against Candida albicans and Saccharomyces cerevisiae [3]. The protein AFP1 isolated from the R. sativus showed antifungal activity against Fusarium culmorum [29]. The R. sativus released biocidal compounds, mainly isothiocyanates, produced during the enzymic degradation of glucosinolates present in the plant cell. The highest fungicidal activity depended on the concentration of isothiocyanates [30]. A neutral fraction of juice R. sativus extract aqueous in vitro showed proliferation inhibition of mouse embryo fibroblast ST3 cells and papovavirus SV40 transformed ST3 cells with IC50 of 17.4 and 6.7 µg/mL [31]. Diamotinoloune (2,4-D) showed highest cytotoxic activity against HeLa cells, 4,4’-methylenedianiline (4,4-D) intermediate, (1,6-D) intermiate, (1,6-D) lowest cytotoxicity. However, the phytotoxicity decreased in the order of 4,4-D >2,4-D>1,6-D [32]. Acetosyringone is an important monocytegenic phenolic signal inducer molecule produced by the plant in response to wounding, which influences the transformation rate of infected plants through the activation of virulence genes [33].

Plant bioactive compounds such as polyphenols and flavonoids are associated with various biological properties including antioxidant activity. These antioxidants act as a redox potential, reducing agents, hydrogen donors, unpaired electrons, singlet oxygen quenchers, or chelate metal cations [34]. The molecular structure and the position of hydroxyl group
in flavonoids determine their antioxidant potential [35]. The phenolic and flavonoid compounds have been reported act as an antimicrobial activity particularly against gram-negative bacteria [36]. The hairy root extract possessing antimicrobial activity against gram-positive Plant Cell, Tissue and Organ Culture and gram-negative bacteria have been reported in several studies [37]. Plant extracts possessing a significant

Table 1: Effects of *Raphanus sativus* L extract on various cancer cell line

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Cell line</th>
<th>Pharmacological effect</th>
<th>References</th>
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<tbody>
<tr>
<td>1.</td>
<td>MDA-MB-231 human breast cancer cells</td>
<td>Reduces expression of ERB2 and ERB3 expression in breast cancer cell line. Over expression of these 2 genes have been identified in most of the breast cancer</td>
<td>[64,65]</td>
</tr>
<tr>
<td>2.</td>
<td>MDA-MB-231</td>
<td>This breast cancer cell line shows reduction in cell viability on treatment with <em>R. sativus</em> leaf and root as well which proves its anti-proliferative activity. <em>R. sativus</em> leaf shows IC50 value 453.2±1.9 mcg/mL and <em>R. sativus</em> root shows IC50 value 470±2.6 lg/mL, where the standard Doxorubicin shows 1.1±0.04</td>
<td>[66,67]</td>
</tr>
<tr>
<td>3.</td>
<td>A549 (Epithelial carcinoma cell line)</td>
<td>This adenocarcinomic human alveolar basal epithelial cell line shows reduction in cell viability on treatment with <em>R. sativus</em> leaf and root as well which proves its anti-proliferative activity. <em>R. sativus</em> leaf shows IC50 value 217±2.1 mcg/mL and <em>R. sativus</em> root shows IC50 value 250.6±3.1 lg/mL, where the standard Doxorubicin shows 1±0.02</td>
<td>[68]</td>
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<tr>
<td>4.</td>
<td>HepG2 (Hepatic Cancer Cell line)</td>
<td>This hepatocellular carcinoma cell line shows reduction in cell viability on treatment with <em>R. sativus</em> leaf and root as well which proves its anti-proliferative activity.</td>
<td>[68]</td>
</tr>
<tr>
<td>5.</td>
<td>MCF-7 (Cell line named after Michigan Cancer Foundation)</td>
<td>MCF-7 is a human breast cancer cell line which can be inhibited by the treatment of <em>R. sativus</em> root and leaves, proving its anti-carcinogenic activity. <em>R. sativus</em> leaf extract has shown inhibitory effect at 703.6 µg/mL on NIH -3T3 which is a I fibroblast cell line</td>
<td>[68]</td>
</tr>
<tr>
<td>6.</td>
<td>NIH-3T3 (Fibroblast Cell line)</td>
<td>DL cell line is a cell line for lymphoma, on which <em>R. sativus</em> leaf has shown very good anti-proliferative effect in the concentration of 423.3 µg/mL.</td>
<td>[69]</td>
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*R. sativus*: *Raphanus sativus*
amount of poly Phenolic compounds often inhibits cell adherence [38]. Among flavonoids, quercetin has the most potent antibiofilm property as it has the ability to inhibit DNA-glyrase, bacterial energy metabolism, and cell membrane function [39].

**Anti-diabetic activity**

Diabetes mellitus is an alarming disease which is caused by loss of glucose homeostasis resulting in high blood glucose level [40]. It is a metabolic disorder & one of the main causes of death every year [41]. The hypoglycemic effect of red *R. sativus* roots may be due to its content of flavonoids and anthocyanins [42]. The consumption of flavonoids or flavonoid-rich foods may reduce the risk of diabetes [43]. Dried red *R. sativus* roots at a concentration 7.5% was identified as the most effective in lowering urine glucose level [44]. *R. sativus* increases the lipid metabolism and lowers the lipid plasma by increasing the activity of lipoprotein lipase [45]. *R. sativus* significantly reduced the starch-induced-postprandial glyceremic load, suggesting that it has a potent antidiabetic activity [46]. Pelargonidin which is an anthocyanin has been found to be effective to reduce blood sugar level [47]. By various mechanism *R. sativus* root extracts have shown the effect in reducing the blood sugar like regulation of hormones related to glucose metabolism, preventing oxidative stress, balancing out sugar uptake and absorption. *R. sativus* root extract has been shown to increase the level of adiponectin which is involved in the regulation of glucose and fat metabolism. Adiponectin found to increase insulin sensitivity, enhancing the bodyweight reduction, increasing fatty acid oxidation, and increasing gluconeogenesis [48].

**Anti-nephrotoxicity activity**

Dimethoate-intoxicated rats showed a constellation of disorders in renal function witnessed by increased urea, creatinine, and uric acid levels [49]. *R. sativus* and leek juices have a high potent protective effect against oxidative stress [50]. *R. sativus* extract and zeaxanthin succeeded in restoring the antioxidant enzyme activities since it caused a significant increase in GSH and SOD activity in the liver and kidney which may be due to the higher content of isothiocyanate, kaempferol glycosides, and L-tryptophan compounds in *R. sativus* extract and their ability to scaveng free radicals [51]. *R. sativus* methanolic extract reversed the decreased levels of reduced GSH and SOD which may be due to the presence of polyphenolic compounds [52]. *R. sativus* and leek juices to dimethoate intoxicated mice restored these altered biochemical parameter levels to within normal limits and improved kidney dysfunction [52]. *R. sativus* exhibits nephroprotection against nephrotoxicity induced by gentamicin. They concluded that this may be due to its potent antioxidant effect [53]. Rifampicin causes acute renal failure and other renal or nephrotoxicity problems [54]. Ethnomedicinal plants reduce nephrotoxicity may be due to their antioxidant properties due to flavonoids, alkaloids, saponins, and tannins present in these plants [55]. Flavonoids like quercetin, is nephroprotective and have been depicted as inhibiting drug-induced nephrotoxicity in experimental animals [56]. Leaves of *R. sativus* contain quercetin which protects the cell lining and hence with the treatments of water extract and ethanolic extract maintained the normal morphology of the kidney [57]. Diuretics are drugs that increase the formation of urine. They act either by increasing the glomerular filtration rate and thus increasing the production of urine. *R. sativus* has excellent diuretic properties [58]. Ethanol and water extract of *R. sativus* have a nephroprotective effect against rifampicin [59].

**Anti-cancer activity**

Cancer is one of the main causes of death and almost one-third of cancers are related to dietary factors [7]. Young *R. sativus* which is a cruciferous vegetable, is rich in vitamin A, vitamin C, and essential minerals which can prevent blood acidification [60]. It contains sulforaphane having quinone reductase activity which inhibits the growth of colon cancer cells [7]. The chemotherapeutic drug like mitomycin C, was used as the positive control for comparing the sensitivity of the cancer cell line to the clinical and conventional anticancer drug as well as with the extract. Mitomycin C possessed a cytotoxicity against the HCT116 cells. The presence of sulforaphane and sulforaphane has already been reported for cruciferous plants [61]. Sulforaphane and Sulforaphane demonstrated a stronger cytotoxicity on PC3 prostate cancer cell line and HCT116 (Table 1), colon cancer cell line than the chemotherapeutic drug (IC50 = 6.67±0.07 and 10.67±0.27 μg/mL, respectively). The Thi chelated *R. sativus* extract possessed a low IC50 indicating its cytotoxicity and suggesting a strong anticancer activity. Saponin-also found in cruciferous plants-was reported to cause some necrotic cell death [62]. Isothiocyanates are reported to inhibit carcinogenesis by various mechanisms [16]. Sulforaphane increases many phase II metabolic enzymes responsible for the reduction of oxidative stress molecules including carcinogens [63]. Sulforaphane reportedly enhances cytotoxic-TRAIL-mediated apoptosis through down-regulation of ERK and Akt in lung adenocarcinomas [5]. *R. sativus* leaves have been used to test anti-cancer effects using various cell lines.

**CONCLUSION**

It becomes very much easy to justify the multi-disciplinary property of *R. sativus* from the above-mentioned detailed discussion. *R. sativus* is such a easily available vegetable for almost all seasons which has got some phytotoxic properties in each of the part of it like fruit and leaf which makes it more potent to work against various lifestyle disorders and also opens a wide path for the intense research on various life-threatening diseases to the world of science.

**AUTHOR’S CONTRIBUTION**

Sakshar Saha, Subham Paul, SK Aman Afroz, Ahana Dey, Atanu Chatterjee, and Ritu Khanra. All gave the same effort to complete the manuscript.

**CONFLICT OF INTEREST**

The researchers claim no conflict of interests.

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