ABSTRACT

Background: Medicinal plants have been commonly used for the treatments of various ailments since pre–historic times. They are cheap and easily available with minimum toxic effects which make them more convenient to use. Objective: This study provides a deep insight to Armoracia rusticana, commonly known as Horseradish, highlighting its medicinal and botanical importance. Methodology: A total of 50 published research articles were thoroughly studied and data was fetched and formulated accordingly. Results: Armoracia rusticana is a perennial and annual crop. Its roots and leaves are used as medicaments. Horseradish extracts are obtained by hot and cold extraction techniques. Phytochemical analysis is followed by Spectroscopy and chromatography for structure analysis and isolation of therapeutic active compounds. Its phytoconstituents include essential oils, sinigrin, sinigrin-derived allyl isothiocyanate and diallylsulphide, vitamin C, glucosinolates and many other compounds. The pungent aroma of Armoracia rusticana is attributed to allyl isothiocyanate. Another reported medicinal compound is Glucosinolate. These are sulfur-containing compounds employed in the prevention of serious illnesses including cancer. Conclusion: The plant as a whole has wide therapeutic applications including anti–bacterial, anti–oxidant and anti–inflammatory action. Therefore it can be used as a basis for further research on its medicinally active constituents and properties.

Keywords: Armoracia rusticana, plant morphology, phytochemical, flavonoids, anti–oxidant.
INTRODUCTION

Owing to the advancement in the phytochemistry and plant science research, scientists have tried to explore various species and kinds of plants for evaluating their chemical and therapeutic potential. Medicinal compounds offer a wide range of chemical constituents which contribute in investigation of their phytochemical properties. This study focuses on a plant commonly known as Horseradish. Its botanical name is Armoracia rusticana which belongs to the Brassicaceae family (1). The Brassicaceae family contains about 3000 different species. Horseradish leaves and roots have been extensively studied for their varying traits. The Armoracia rusticana have many common names in different region such as horseradish, red horseradish, creole, german mustard, red cole and horse-radish root (2). This review article comprises of data collected from already available published literature evidences on Horseradish plant. It covers all the major aspects related to the plant parts and their characteristic features. A brief account of this plant has been given in the article based on the investigations made in the recent years.

Origin and distribution

Horseradish plants are cultivated in the reign of North America, Russia, Europe, Asia and New Zealand. (3, 4). Armoracia rusticana are produced annually and about 7*10 kg of plant is utilized as food in USA. In the USA, 1500 acres crop are produced. (2). The temperature conditions for suitable growth of Armoracia rusticana is 5 to 19 °C with pH ranging from 5 to 7.5. In North America, the Armoracia rusticana are cultivated in slightly wet and shadow environment. The soil rich in loam and organic matter is considered to be the most suitable one for Armoracia rusticana cultivation.

Characteristics and morphology

Horseradish has a very pungent odor with biting taste. (5). Root of this plant has fresh white inner side and dark brown outer side. The roots does not have any flavor of their own while the cutting gives pungent, mustard like smell which disappears promptly. (2). Horseradish has the capability to live in frozen and boiling temperature. Horseradish plants are propagated by the pieces of root. (2). A circular arrangement of leaves can be seen on the top of Horseradish plant. Leaves are large, paddle-shaped with flower stalk and produce seeds. (8-11). Flowers are white in color with honey like odor. As a perennial crop, its long yellowish-buff taproot bears long-stalked ovate or oblong leaves (30-100 cm in length) with coarsely toothed, wavy margins. (10). Its flowers are
white racemes with four sepals and petals with six stamens. Its fruit is a silique (4). It seeds are visible. Morphology of the plant is different in the different season. The horseradish plant has laminate leaves in the season of summer but it is changed into pinnate leaves in the season of autumn (12).

**Production, Collection and cultivation**

*Armoracia rusticana* plants are perennial in Europe and annual crop in open field in United States of America (7). The perennial crop, however, requires a long term investment of 20 years. The plant height is 120 cm (8). Horseradish plants are cultivated in such a way that a horizontal distance of 60 cm distance exists between plants horizontally and 70 cm in between the rows (14-20). Mature roots are collected in April and given to consumers. Some roots are stored to be utilized in upcoming year (15). Roots are used for propagation. For profit oriented production, horseradish plants are cultivated rapidly in spring season due to high temperature (17). The growth takes place in fall season, owing to the low temperature. At the end of growing season, the diameter of roots is increased whereas length remains same. The growing season is October and November (18). Horseradish roots are collected in the season of spring, early winter, or autumn (19). The roots are grounded into powder and leaves are dried and stored into airtight container (5).

**Process of extraction**

The extraction of volatile compounds is carried out by steam distillation (52) and others by solid phase micro extraction, supercritical fluid extraction, maceration and percolation (45, 50). Extraction is followed by separation and isolation of chemical constituents using HPLC and spectrometry.

**CHEMICAL CONSTITUENTS**

The major chemical constituents include volatile oil, polyphenols, terpenoids, and polysaccharides. The composition of volatile oil is 0.05% to 0.2% (22). Horseradish also contains essential oils. The concentration of essential oil is about 0.2 -10% (25). Other volatile oils include Thiobismethane, Carbon disulphide, 3-Butenenitrile, 3-Methylbutanal, 2-Ethylfuran, 3-Methyl-1-butanol, Toluene, Hexanal, E-2-hexenal, Heptanal, Benzaldehyde, Isobutyl isothiocyanate, 4-Isothiocyanato-1-butene, 2-Pentylfuran, Butyl isothiocyanate, 2-Ethyl-1-hexanol.
, Phenylacetaldehyde, 3-Methylbutyl isothiocyanate, Pentyl isothiocyanate, Nonanal, 4-Ethylbenzaldehyde, 4-Methylpentyl isothiocyanate, L-(-)-Menthol, Naphthalene, Decanal, Benzenepropanenitrile, Junipene and Italicene (17-25). Horseradish also contains phenols, flavonoids, 2-phenylethyl glucosinolate and sinigrin. The active constituents are sinigrin, asparagine and resin. Sinigrin, a glycoside, when combined with water yields mustard oils. About 120 structurally different glucosinolates have been described in literature. Armoracia rustica contains glucosinolates which have high level of sulfur-containing glycosides. (31). Glucosinolates contain Glucoiberin, Sinigrin, 2-Methylsulfonyl-oxo-ethyl-GLS, Gluconapin, Glucoconringianin, Glucosativin, Glucoiberin, 4-HydroxyGlucobrassicin, Glucocochlearin, 5-Hydroxyglucobrassicin, Glucocapparilinearisin, Glucobrassicanapin, Glucotropaeolin, Glucobrassicin, Gluconasturtiin, 4-Methoxyglucobrassicin and Glucoarabishirsutain (14,15). Glucosinolates are broken down into isothiocyanates (ITCs) and others sulfur compounds (2-phenylethyl isothiocyanate) as a result of which flavour and aroma are produced (20). Sinigrin breaks down into allyl isothiocyanate. 83% of sinigrin is present in the horseradish roots and 91% in its leaves. (23,24). Horseradish root contains vitamins in abundant concentration, specifically vitamin C. (3). Horseradish roots contain glucobrassicin, glucobrassicinapin, glucocapparin, glucocheirolin, glucoiberverin, glucocochlearin, glucoiberin, glucolepidiin, gluconapin and glucotropaeolin. Horseradish roots have high volatility of the oil. They also contain B1, minerals, phytoncide, essential oils, phenolic compounds, enzymes, kaempferol and quercetin. Horseradish is a rich source of peroxidase enzyme as well (29,33,34). Certain phytoconstituents are described with the structures below.

Carbon disulphide

\[
\begin{align*}
S & = C \equiv S \\
R & \equiv N \equiv C \equiv S
\end{align*}
\]
**Sinigrin**

Isothiocyanate

4-Hydroxyglucobrassicin

Glucosinolates

5-Hydroxy Glucobrassicin

Glucoiberin

Gluconapin

Glucosativin
Ascorbic acid (Vitamin C)  
Benzyl isothiocyanate

Fig. 8 Structures of various phyto constituents of Armoracia rusticana or horseradish.

USES

Traditional uses

The root of Horseradish is used in sauces and pastes. Their leaves are use in salad and sandwiches. (5). Roots are boiled, washed, and mixed with salt and sugar to remove the isothiocyanates which causes its pungent taste. (47, 48).

Medical use

Horseradish is a source of many biologically active compounds. It has antiscorbutic property, antimicrobial action and anti-oxidant property. The horseradish also is a rich source of glucosinolates and their isothiocyanates derivatives, vitamins and peroxidase enzyme that they are help to treatment for bladder, breast, and nasoesophageal cancer. Horseradish is also used in cosmetics industry for the bleaching purpose. (40-43). Antibacterial characteristic is due to isothiocyanates which are obtained from horseradish. (53). Horseradish is used for the treatment of urinary tract infections and bronchitis. It is also used as a remedy against lung and heart diseases. Horseradish plants are beneficial for wounds, fever and pain. It relieves headaches, hypertension and treats gout, different kinds of nasal and sinus dysfunctions, lower back pain and rheumatism, respiratory aid, for toothache and helps against digestive problems (51). It is used to treat Influenza (39) and skin problems. It lowers fever by increasing perspiration, acts as a diuretic, stimulant, diaphoretic, digestive and also stimulates circulation. The fresh root of
Horseradish has been considered to use as antiseptic, diaphoretic, rubefacient, stomachic and vermifuge, asthma, anti-inflammatory, coughs, colic, scurvy, toothache, ulcers and venereal diseases (46). Horseradish act as anti-cancer by suppressing the carcinogen-activating enzymes and thus inhibits the cytochrome carcinogen-detoxifying enzymes. Cytochrome p450 enzymes are also called carcinogens-activating enzymes as they help to convert pro-carcinogen into carcinogen compounds (40-44). The enzyme horseradish peroxidase has helped to remove the free radical and waste components which are produced in the body. It also has several applications in laboratory and medical industry (35,36). Horseradish root it also act as poisoned when take larger amount. Horseradish root also possesses herbicidal activity.

Conclusion

Armoracia rusticana or horseradish plant is diverse in nature. Every plant part of horseradish plays a significant role in its utility and benefit. This review presents a complete picture of rich phytoconstituents and their contribution in combating various ailments and diseases. Our study lays emphasis on the fact that plant parts of horseradish should be exploited further in order to evaluate its therapeutic efficacy. Such studies set the stage for the researchers to explore the medicinal value and then prove it by the clinical findings.

Authors’ contributions
AY contributed to study concept; FQ, AAM and OA contributed to data analysis, literature review, write and critically review the manuscript. All the authors read and approved the final manuscript.

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