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Mustard Magic: A Palate-Pleasing Review

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Abstract

This comprehensive review article explores the medicinal properties and key bioactive components of *Brassica juncea*, *Brassica nigra*, and *Sinapis alba*. These three members of the Brassicaceae family have long been recognized for their therapeutic potential. We provide an in-depth analysis of the bioactive compounds present in each plant, shedding light on their pharmacological properties and potential health benefits. From anti-inflammatory, analgesic and antioxidant effects to potential anticancer properties, we examine the diverse medicinal applications of these Brassica species. This review aims to consolidate current knowledge on the subject, offering a valuable resource for researchers, healthcare professionals, and individuals interested in the medicinal aspects of *Brassica juncea*, *Brassica nigra* and *Sinapisalba*.

Keywords : *Brassica juncea*, *Brassica nigra*, *Sinapis alba*, Anti-inflammatory, Analgesic, Anti-oxidant, Anticancer.

INTRODUCTION

Mustard is a very old spice mentioned in Sanskrit writings from around 3000 BC. It was alsoone of the first plants that people started to grow on purpose. At first, it was used as a type of seasoning called "mustard," which comes from the Latin word "mustum" The Romans made a special kind of sauce by mixing crushed mustard seeds with grape or fruit juice, and they called it "mustum ardens," which means "hot or burning sauce" [1]. Hippocrates and several other historical physicians employed mustard seeds for medicinal purposes. In the 20th century, the role of mustard transformed from a medicinal agent to a popular spice or condiment. This shift was so significant that mustard emerged as the predominant spice in terms of trade volume ona global scale [2]. Recently, many people are getting interested in getting healthier and fitter byusing things that are more natural. People have been using herbs and spices for a really long time to make food taste better, look prettier, and smell nice. In the past, lots of different plants were used to help fight off illness. Mustard is one of those plants that has been used as medicinefor a really long time, like hundreds of years [3]. Nowadays three types of mustards are widely used for various purposes: *Sinapis alba* (white mustard), *Brassica juncea* (Indian mustard), and*Brassica nigra* (Black mustard).

▪ ***Brassica juncea* :**
Brassica juncea is commonly known as Indian mustard, Chinese mustard, oriental mustard, leaf mustard, and mustard green. It belongs to the Brassicaceae family. This plant is important because it is useful for many things like medicine and nutrition. People in India have known about its benefits for a long time [4].

▪ ***Brassica nigra* :**

Brassica nigra is a plant which is commonly known as Black mustard, Mohntrdae Louie, etc. It is an annual herbaceous plant that is used for various medicinal purpose. It's parts and oil contain various medicinal values [5]. Within temperate climates, *Brassica nigra* was a preliminary cultivar of mustard until1950s, when it was supplanted in commercial cultivation by its near kin, *Brassica juncea.* Currently, *Brassica nigra* has transitioned into a prevalent and widespread weed [6].

▪ ***Sinapis alba* :**

Sinapis alba is commonly known as white mustard. Which has been cultivated since 3,500 BC[7]. Sinapis semen refers to the dried, fully developed seeds derived from the Sinapis alba plant. These seeds are utilized in combination with other herbal components as a part of clinical innervations to address a range of medical conditions.The utilization of Sinapis semen, when blended with various herbs, forms the basis of therapeutic approaches for diverse diseases [7].

TAXONOMY

1. *Brassica juncea* : [9]

Kingdom	Plantae
Division	Mangnoliophyta
Class	Magnoliophyta
Subclass	Dilleniidae
Order	Capparales
Family	Brassicaceae
Genera	Brassica
Species	*Brassica juncea*

2. *Brassica nigra* : [10]

Kingdom	Plantae
Division	Spermatophyta
Class	Dicotyledonae
Order	Capparidales
Family	Brassicaceae
Genus	Brassica
Species	*Brassica nigra*

3. *Sinapis alba* : [11]

Kingdom	Plantae
Division	Tracheophyta
Class	Magnoliopsida
Order	Brassicales
Family	Brassicaceae
Genus	Sinapis
Species	*Sinapis alba*

Botanical characteristics

A. Brassica juncea :

Brassica juncea has its beginnings as an amphidiploid possessing 18 chromosomes. Researchers suggest it emerged from natural cross-breeding between *Brassica nigra*, which has 8 chromosomes, and *Brassica rapa*, which has 10 chromosomes. The probable origination of *Brassica juncea* is in regions like the Middle East, where the habitats of *Brassica nigra* and *Brassica rapa* intersect [12].

Mustard plants have the potential to attain a height of 150cm. When young, both stemsand leaves are covered in bristles. The stems stand upright, while the lower leaves are smaller and exhibit notched or toothed edges. On the other hand, the upper leaves are narrow and lance-shaped, with edges that are earlier sparsely toothed or completely smooth. Typically, the flowering of mustard occurs during the months of March to May,followed by fruiting from May to June. Mustard is known for its brief growth cycle, taking only about 30 days from seed

sowing to harvest. The ideal temperature range forits growth lies between 15-22°C [13]. (Fig-1).

B. *Brassica nigra* :

This plant is a yearly, stiff, upright herb that typically reaches a height of 40-90(-120)cm, with branching and a somewhat hairy texture. The lower leaves are lyrate, deeply pinnatifid or dissected, measuring 6-20 x 4-12 cm, while the upper ones are smaller, sessile or short-stalked, narrowly elliptic or lanceolate, and generally unbroken. The inflorescence takes the form of a branched raceme, densely packed with 40-50 flowers. The flowers themselves are around 1.2 cm in diameter, with pedicels 3-5 mm long andlacking bracts. The sepals are oblong, obtuse, and 4-5 mm long, with a smooth surface.The petals are obovate, possessing long claws and measuring 8-10 mm in length, showcasing a bright yellow hue. The stamens are approximately 4 mm long. The fruitsare oblong, ranging from 1-2 cm x 1-2.5 mm, with a 2-3 mm long beak and devoid of seeds. The valves are keeled and torulose, containing 3-5 seeds in each locule, with theseeds being roughly 1 mm in diameter, smooth, and dark brown. [14],(Fig-2).

C. *Sinapis alba* :

Sinapis alba is a type of plant that is planted in the spring and its seeds are collected in the fall. It grows quickly and becomes quite tall, around 5 to 6.5 feet. During early summer, it gets covered in lots of flowers, but they eventually fade and turn into fruits.White mustard can grow well in different kinds of soil and can handle tough weather. It doesn't have many problems with bugs or diseases. People in many countries use machines to grow and harvest it [15]. (Fig-3).

[A] [B]

[**Fig – 1 :** (A) *Brassica juncea* seeds , (B) *Brassica juncea* plant**]**

[A] [B]

[Fig – 2 : (A) *Brassica nigra* seeds , (B) *Brassica nigra* plant**]**

[A] [B]

[Fig – 3 : (A) *Sinapis alba* seeds , (B) *Sinapis alba plant***]**

MEDICINAL PROPERTIES

Mustard is a versatile plant that has been revered for its remarkable medicinal properties throughout history. From ancient civilizations to modern science, The mustard plant's seeds, leaves, and oil have been harnessed for their potential to heal and enhance well-being. The mustard's rich medicinal heritage intertwines traditional wisdom with scientific exploration, offering a glimpse into the plant's multifaceted contributions to health. From digestion supportto pain relief and respiratory well-being, the multifaceted attributes of mustard are poised to inspire a new appreciation for this humble plant's remarkable contributions to human health.

I. *Brassica juncea* :

Brassica juncea has various medicinal properties attributed to its different parts :

Seeds :
The seeds of *Brassica juncea* stand out as a potent source of therapeutic compounds. These seeds have been utilized in traditional medicine systems for centuries due to their diverse array of health-promoting attributes. The seeds contain various Medicinal properties which may include :

Anti-inflammatory: The seeds of *Brassica juncea* contain compounds with anti- inflammatory properties which are useful in the treatment of Abscesses and colds [16].

Hypoglycemic properties : The seeds of *Brassica juncea* also contain hypoglycemic properties which are useful for the treatment of Hyperglycemia and used to control increased blood sugar levels [17].

Diuretic: Some mustard preparations can aid in treating conditions like Hypertension and Edema due to their diuretic effects. These preparations may include Mustard seed tea which has a mild diuretic effect. To make it, crush or grind mustard seeds, steep them in hot water, and then strain the liquid. Consuming this tea in moderation may help to promote urine production [18].

Oil :
The oil which is derived from the seeds of *Brassica juncea* stands out as a valuable natural remedy with a range of therapeutic applications. This versatile oil, excreted from the seeds of the *Brassica juncea* plant, has been generated for its potential health benefits and healing properties. It includes the following medicinal properties:

Analgesic : The oil contain analgesic properties. so, mustard oil has the ability to relieve pain and discomfort when applied topically or used in massages. It is useful for the treatment of Backache, Footache, Rheumatism, Neuralgia, etc [16],[17],[18].

Hepatoprotective: The oil also contains Hepatoprotective properties which are beneficial for the treatment of various liver diseases like Cirrhosis, Hepatitis, and Jaundice [18].

The Therapeutic effects and medicinal properties of seeds of *Brassica juncea* is given below (Table 1).

Leaves :
The leaves of *Brassica juncea* have been recognized for their potent health benefits, making them a valuable addition to traditional and modern medicinal practices. The medicinal properties of leaves include :
Antioxidant: *Brassica juncea* leaves contain Antioxidants, Vitamin A & Vitamin. Antioxidants fight aging by reducing free radical damage, Vitamin A supports skin regeneration and reduces wrinkles and Vitamin C boosts collagen and reduces the fineline [19].
Anti-viral: *Brassica juncea* leaves offer potential benefits in viral respiratory infections, Influenza, Oral Herpes, and Genital Herpes due to their Anti-viral properties which boost the immune system against respiratory viruses [19].

Anti-microbial: Leaves of *Brassica juncea* exhibit potent antimicrobial properties effective against skin, fungal, and bacterial infections offering natural therapeutic potential [20].

Anti-obesity: *Brassica juncea* leaves aid in combating obesity due to their natural anti-obesity properties[21].

Antiatherogenic: The leaves of *Brassica juncea* exhibit antiatherogenic effects and reduce the risk of atherosclerosis[22].
Anti-tumor: *Brassica juncea* leaves exhibit potential antitumor effects which may aid in treating tumors [22].

Anti-cancer: *Brassica juncea* leaves have shown potential anticancer activity primarily against certain types of cancer, including colon cancer, Colorectal cancer, Breast cancer, etc[23].
The consumption of *Brassica juncea* leaves and other cruciferous vegetables has been associated with a reduced risk of colon and colorectal cancer.
There is ongoing research into the potential protective effects of *Brassica juncea* leaves against breast cancer, as they contain compounds that may help to regulate hormone metabolism, which can be relevant to breast cancer risk.

The Therapeutic effects and medicinal properties of *Brassica juncea* leaves is given below (Table 2).

Botanical Name	Parts used	CommonName	Symptoms/Diseases	Medicinal properties	Form of application	References
Brassica juncea	Seeds	Brown mustard seeds, Marisa, Sarson, Rai, Kadugu, Gai choy	Abscess	Anti-inflammatory	Mustardpaste	[16]
			Backache	Analgesic	Mustardpaste & Mustard oil	[16]
			Foot ache	Analgesic	Mustardpaste & Mustard oil	[16]
			Rheumatism	Analgesic	Mustardpaste	[17]
			Cold	Anti-inflammatory	Mustard oil	[17]
			Diabetes (Hyperglycemia)	Hypoglycemic agent	Mustard oil	[17]
			Jaundice	Hepatoprotective agent	Mustardplaster OR Poultice	[18]
			Neuralgia	Analgesic	Mustardseed Tea	[18]
			Hypertension,Edema	Diuretic		[18]

[TABLE-1: Therapeutic effects and medicinal properties of *Brassica juncea* seeds]

Botanical Name	Parts used	Common Name	Symptoms/Diseases	Medicinal properties	Form of application	References
Brassica juncea	Leaves	Mustard greens, Mizuna, Korean mustard greens, Sorshe, Mustard mallum, Jie cal	Aging (Wrinkles, Finelines& Skinhealth)	Anti-oxidant	Fresh salad& smoothie of mustard greens	[19]
			Viral respiratory infections, Influenza, Genital Herpes, Oral Herpes	Anti-viral	Fresh salad& wrap	[19]
			Skin infections, Fungal infections, Bacterial infections	Anti-microbial	Crushed leaves, Tinctures, Extracts of leaves, Soup	[20]
			Obesity	Anti-obesity	No Data Leaf extract Leaf extract	[21]
			AtherosclerosisTumor	Antiatherogenic		[22]
			Cancer	Anti-tumor Anti-cancer	Leaf, Extract, Cooked dishes.	[22] [23]

[TABLE-2: Therapeutic effects and medicinal properties of *Brassica juncea* leaves]

II. *Brassica nigra* :

Brassica nigra has various medicinal properties attributed to its parts :

Seeds :

Brassica nigra seeds also known as Black mustard seeds, are widely utilized in culinary and traditional medicine, and possess a treasure trove of health-enhancing properties. Itoffers a natural and versatile remedy. The medicinal properties of Black mustard seedsinclude :

Analgesic: Black mustard seeds contain Pain-relieving properties so it is an effective analgesic to treat various diseases like Rheumatoid arthritis, joint pain, neuralgia etc [24],[26].

Antioxidant: Black mustard seeds contain a high amount of Antioxidants and Phenolic compounds which possess significant potential in treating various diseases like Cardiovascular issues, cancer, and diabetes [25].

Antiinflammatory: Black mustard seeds contain phytochemicals that can help to modulate the inflammatory response within the body by influencing various pathwaysand mediators involved in inflammation [26].

Kidney stone management: In recent research, the potential of *Brassica nigra* seeds to aid in kidney stone management has been explored. These seeds contain bioactive compounds that may contribute to the dissolution of certain types of kidney stones andthe prevention of their recurrence [27].

Digestive agent: The black mustard seeds are traditionally used as digestive agents. It can promote the digestion and overall gastrointestinal health [28].

Anti-microbial agent: The black mustard seeds encompass their ability to inhibit the growth or activity of various microorganisms, including bacteria, fungi, and possibly even viruses [29].

Emetic agent: The black mustard seeds have the ability to induce vomiting, which has been harnessed for therapeutic and purgative purposes. These seeds contain bioactive components that irritate the gastric mucosa lining in the stomach and induce vomiting
[30].

The Therapeutic effects and medicinal properties of *Brassica nigra* seeds are given intable-3.

Leaves :
The medicinal properties of *Brassica nigra* leaves offer a fascinating avenue for exploration in the field of herbal and alternative medicine. These leaves are widely recognized for their culinary uses and therapeutic qualities. These leaves have been traditionally used in various cultures to address a spectrum of health concerns and ailments. The leaves contain various medicinal properties which include :

Anti-oxidant: The antioxidant properties of black mustard leaves operate through a mechanism involving the phytochemicals present in them. These compounds act as scavengers, neutralizing free radicals and mitigating oxidative stress. This mechanism contributes to the beneficial effects of black mustard leaves on cardiovascular health and skin [31],[32].

Nutrient: leaves of black mustard are a significant provider of vitamin K, offering various nutritional advantages. Vitamin K1, present in these leaves, is vital for maintaining bone health as it plays a crucial role in the production of bone proteins [33].

Anti-ulcer agent: There is some evidence indicating that specific components in the leaves of Brassica nigra could potentially offer protection against ulcers. Extracts fromBrassica nigra may stimulate increased mucus production in the stomach, serving as a protective shield for the stomach lining [34].

Anti-bacterial agent: The leaves of *Brassica nigra* contain bioactive compounds which have demonstrated antibacterial properties, these compounds can inhibit the growth andreplication of bacteria [35].

Hepatoprotective agent: *Brassica nigra* leaves contain bioactive components which enhance the liver's natural detoxification processes by promoting the production of enzymes involved in breaking down and eliminating toxins [36].

The Therapeutic effects and medicinal properties of *Brassica nigra* leaves are given inTable-4.

BotanicalName	**Parts used**	**Common Name**	**Symptoms/ Disease**	**Medicinal properties**	**Form of application**	**References**
Brassica nigra	Seeds	Black Mustard Seeds, Rai, Sarson, Kadugu, Mohri, Moutarde Noire, Sachwarzer Senf, Monstarda, Rai Kuria, Rai Mohri	Rheumatism, Neuralgesia	Analgesic	Mustard plasters OR Poultices	[24]
			Aging, Immune support	Antioxident	Grinded seeds,Oil, Powder	[25]
			Granuloma	Analgesic	Mustard oil & Mustard paste	[26]
			Edema	Anti-inflammatory	Mustard oil& Mustardpaste	[26]
			Kidney stone	Kidney stone management	No Data	[27]
			Indigestion, Constipation	Digestive aid	CondimentOR Spice	[28]

			Fungal infections	Anti- microbial		[29]
			Accidental Poisoning, Food Poisoning	Emetic	Ethanolic extract of seeds, Powder of seeds	[30]

[TABLE-3: Therapeutic effects and medicinal properties of *Brassica nigra* seeds]

BotanicalName	Partsused	CommonName	Symptoms/ Diseases	Medicinal properties	Form of application	References
Brassica nigra	Leaves	Black Mustard greens, Mizuna, Gat kimchi,Bhaji, Mustard bush	Hypertension, Stroke	Anti-oxidant	Leaf extract	[31,32]
			Aging Wrinkles			
			Osteoporosis	Vitamin-K (Nutrient)	No Data	[33]
			Gastric Ulcers		Leaf extract	[34]
				Anti-ulcer	Leaf extract	
				Antibacterial	Leaf extract	
			Bacterial infections	Hepato-protective agent		[35]
			Hepatic and Renal damage			[36]

[TABLE-4: Therapeutic effects and medicinal properties of *Brassica nigra* Leaves]

III. *Sinapis alba* :

The various parts of *Sinapis alba* contain different medicinal properties which are as follows:

Seeds :

Sinapis alba seeds are commonly known as white mustard seeds. White mustard seeds are valued for their remarkable medicinal properties. It possesses a hidden treasure trove of therapeutic potential. The medicinal properties of *Sinapis alba* seeds are givenbelow :

Anti-inflammatory agent: Sinapis alba seeds contain various bioactive compounds. These compounds have been studied for their potential anti-inflammatory properties. They may modulate inflammatory pathways and reduce the production of pro- inflammatory molecules in the body [37].

Anti-proliferative agent: White mustard seeds comprise diverse polyphenolic compounds, which play a role in shielding cells from oxidative harm and modulating signaling pathways related to cell proliferation. [38].

Anti-microbial agent: White mustard seeds contain various phytochemical compounds,which can break down into bioactive compounds upon crushing or chewing. which exhibits antimicrobial properties [39].

Immunomodulator: some research suggests that compounds found in *Sinapis alba* seeds may have immunomodulatory effects. Immunomodulation refers to the regulation or modulation of the immune system's activity. The potential immunomodulatory properties of Sinapis alba seeds may be attributed to the presence of bioactive compounds. which have been investigated for their effects on the immune system. These compounds can stimulate various immune responses [40].

Anti-oxidant: The capacity of Sinapis alba seeds to function as antioxidants is linked to specific bioactive compounds within them. These compounds possess the capability to eliminate free radicals and counteract their detrimental effects, thereby diminishing oxidative stress within the body. [41].

Emetic: White mustard seeds are traditionally used as an emetic agent, which can irritate the stomach lining and trigger a vomiting reflex. This property has been utilizedin the past for therapeutic purposes, such as to induce vomiting in cases of poisoning or to clear the stomach of unwanted substances [42].

Anti-fungal agent: White mustard seeds contain bioactive compounds including volatile compounds, which are responsible for their pungent taste and aroma, which shows anti-fungal activity [43].

Anti-obesogenic agent: White mustard seeds contain bioactive components that may help to prevent or reduce obesity by influencing factors such as appetite, metabolism, or fat storage [44].

Anti-hypertensive agent: white mustard seeds contain various bioactive compounds that may help to reduce high blood pressure [45].

Anti-bacterial agent: Sinapis alba seeds contain bioactive compounds, which have been reported to have antimicrobial properties, including antibacterial effects. They can inhibit the growth of various bacteria [46].

The therapeutic effects and medicinal properties of *Sinapis alba* seeds are given inTable 5.

Leaves: Sinapis alba leaves, commonly known as white mustard greens, its medicinal properties, primarily associated with its leaves. The plant has a long history of use in traditional herbal medicine. Here's an introduction to some of the medicinal propertiesof Sinapis alba leaves:
Anti-oxidant: White mustard greens contain bioactive components that are responsible for antioxidant properties. They can help to combat oxidative stress in the body [47].

Anti-bacterial agent: White mustard greens contain various bioactive components which are responsible for their antibacterial properties. Which inhibits the growth of bacteria and helps to prevent bacterial infections [48].

The therapeutic effects and medicinal properties of *Sinapis alba* leaves are given in Table 6.

Botanicalname	Partsused	Commonname	Symptoms/ Diseases	Medicinal Properties	Form of application	Reference
Sinapis alba	Seeds	White mustard seeds, Yellow mustard, Wild mustard, Safed sarson, Yellow charlock, Sinapissemen	Arthrities, Muscle pain Cancer, Psoriasis Bacterial andfungal infections Auto-immune diseses, Allergy Breast cancer, Prostate cancer Poison induction, Overdose Fungal infections Obesity Hypertension	Anti-inflammatory Anti-proliferativeagent Anti- microbial agent Immuno-modulator Anti-oxidant Emetic Antifungalagent Anti- obesogenic agent	Seed extract Seed extract Seed extract Ethanolic seed extract Seed extract Powder,Paste Powder Powder Seed extract	[37] [38] [39] [40] [41] [42] [43] [44] [45]
			Bacterial infections	Anti-hypertensive agent Anti-bacterial agent	Seed oil	[46]

[Table-5: Therapeutic effects and medicinal properties of *Sinapis alba* seeds]

Botanicalname	Partsused	Common name	Symptoms/ Diseases	Medicinal properties	Form of application	Reference
Sinapis alba	Leaves	White mustard greens, Yellow leaf mustard	Cardiac andskin problems Bacterial infections	Anti-oxidant Anti-bacterial	Poultices, Powders, Herbal Tea Leaf extracts, Poultices	[47] [48]

[Table-6: Therapeutic effects and medicinal properties of *Sinapis alba* leaves]

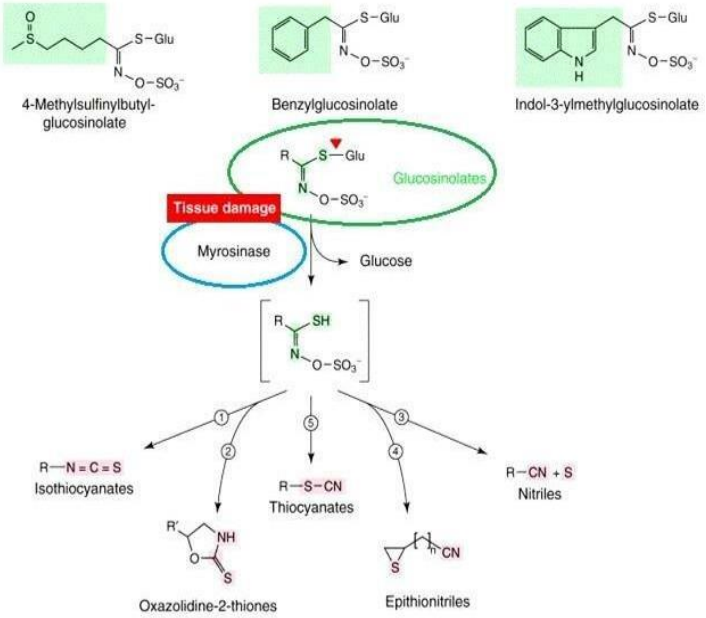
BIOACTIVE COMPOUNDS

Sinapis alba (white mustard), *Brassica juncea* (brown mustard), and *Brassica nigra* (black mustard) are all members of the Brassicaceae family and share some common bioactive compounds, although the exact composition and concentrations of these compounds can vary between species. Here's an introduction to some common bioactive compounds found in thesemustard plants:

1) Glucosinolates :

Glucosinolates are a group of sulfur-containing compounds found in varying amounts in all three mustard

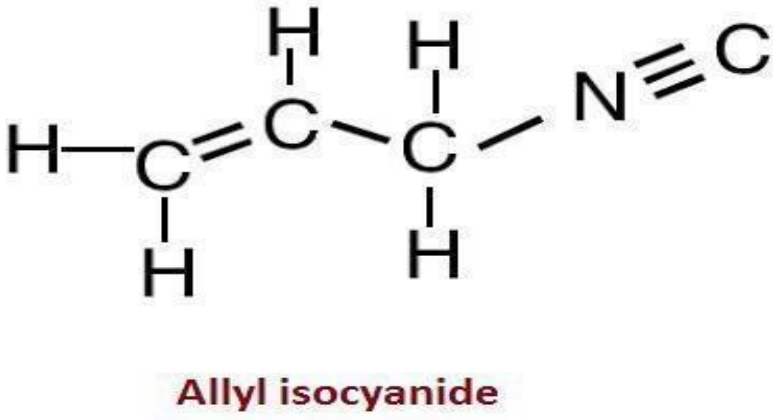
species (*Brassica juncea, Brassica nigra and Sinapis alba*). When plant tissues are damaged, such as during chopping or chewing, glucosinolates come into contact with the enzyme myrosinase, leading to the formation of various bioactive breakdown products (Fig-4). These breakdown products, such as isothiocyanates and indoles, are known for their potential health benefits, including anti-cancer and antioxidant properties. Different mustard species may have different types and concentrations of glucosinolates [49].



[Fig-4: Formation of various bioactive breakdown products from Glucosinolates]

2) Allyl isothiocyanates :

Bioactive compounds called allyl isothiocyanates are present in several plants, including *Brassica juncea*, commonly known as brown mustard. These compounds, responsible for the distinctive pungent flavor and aroma of mustard, are generated through the enzymatic breakdown of glucosinolates in the mustard plant's tissues by theenzyme myrosinase. The specific allyl isothiocyanate originating from Brassica junceais referred to as "allyl mustard oil" (Fig-5). Allyl isothiocyanates, such as those from Brassica juncea, have been the subject of research due to their potential health benefits, encompassing antimicrobial, anticancer, and anti-inflammatory properties. They also contribute to the spiciness or "heat" of mustard, making it a widely favored condiment [50]. While *Brassica nigra* seeds also contain AITC, the content may be slightly lower compared to *Brassica juncea*. *Sinapis alba* seeds also contain AITC, but the AITC content is typically lower than that found in brown and black mustard seeds.

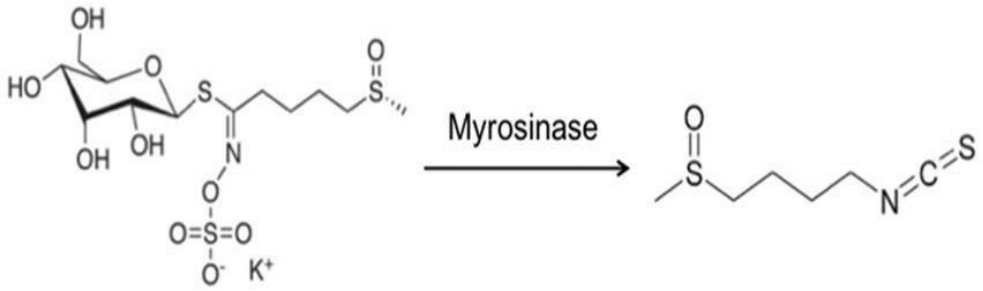


[Fig-5: Structure of allyl isothiocynate]

3) Sulforaphane :

Sulforaphane is a sulfur-containing compound that is formed when the enzyme myrosinase acts on glucoraphanin, a precursor found in Brassica juncea and other cruciferous vegetables (Fig-6). Sulforaphane

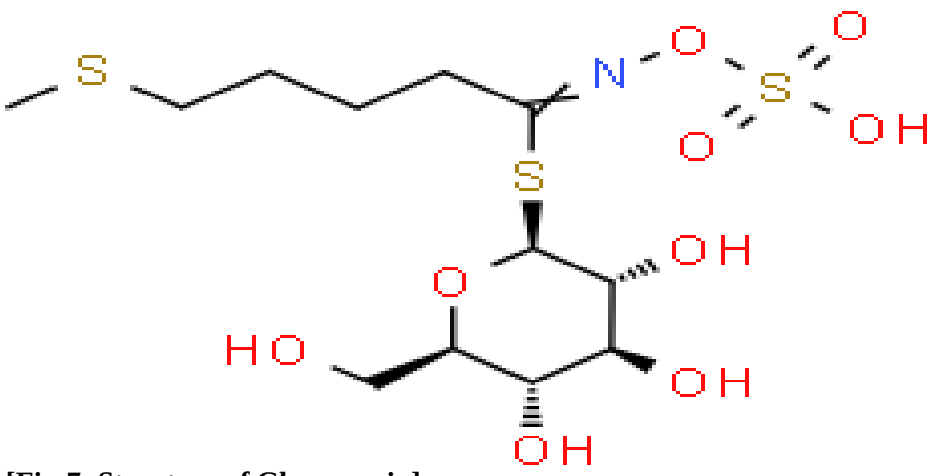
has been of interest in the context of diabetes and its potential anti-diabetic effects. Some research suggests that sulforaphane may improve glucose metabolism and insulin sensitivity. It can potentially help regulate blood sugar levels and reduce insulin resistance [51].



[Fig-6: Formation of sulforaphane from glucoraphanin]

4) Erucin :

Erucin is a naturally occurring isothiocyanate found in certain cruciferous vegetables, including Brassica juncea. Generally, Glucoerucin is found in Brassica juncea which is responsible for anti-obesogenic effects (Fig-7). Isothiocyanates are a group of bioactive compounds that have been studied for their various health benefits, including potential anti-obesity effects. Some studies have suggested that erucin may have metabolic effects, including improving insulin sensitivity and potentially modulating lipid metabolism. These effects can influence body weight and fat accumulation [52].



[Fig-7: Structure of Glucoerucin]

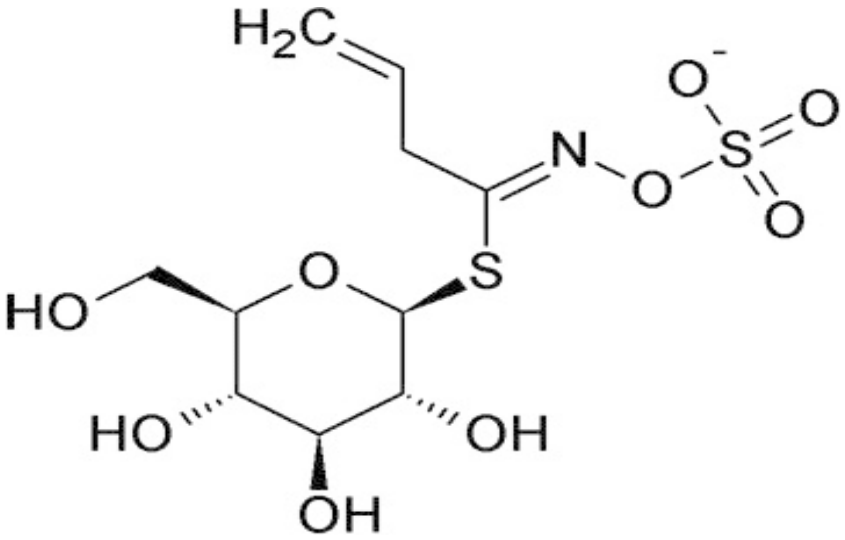
5) Dietary fibers :

Cruciferous vegetables like black mustard contain dietary fiber. Dietary fiber can help prevent kidney stone formation by binding to calcium in the intestines, reducing the amount of calcium that enters the urinary system. This, in turn, may help reduce the risk of certain types of kidney stones, such as calcium oxalate stones [53].

6) Sinigirin :

Sinigrin is a natural compound found in plants, specifically in those of the Brassicaceae family (fig-8), which includes Brassica nigra (black mustard) among other species. Sinigrin is classified as a glucosinolate, a type of secondary metabolite that contains sulfur. These compounds play several roles in plants, including defense against herbivores and pathogens, as well as contributing to the plant's distinctive flavors and aromas. Sinigrin can induce vomiting when ingested in sufficient quantities. In cases of poisoning or accidental ingestion, healthcare professionals have used sinigrin as an emetic to induce vomiting and help remove potentially

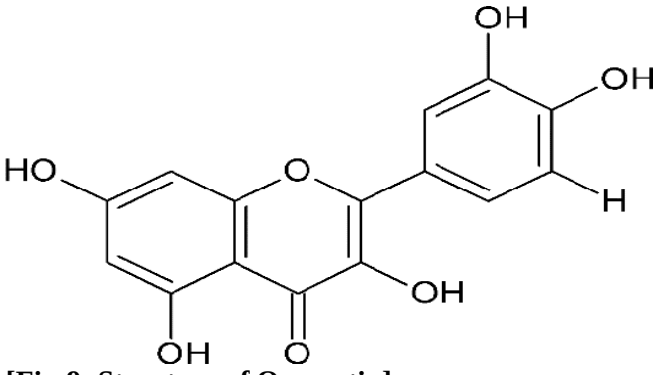
harmful substances from the stomach[54].



[Fig-8: Structure of Sinigirin]

7) Quercetin :

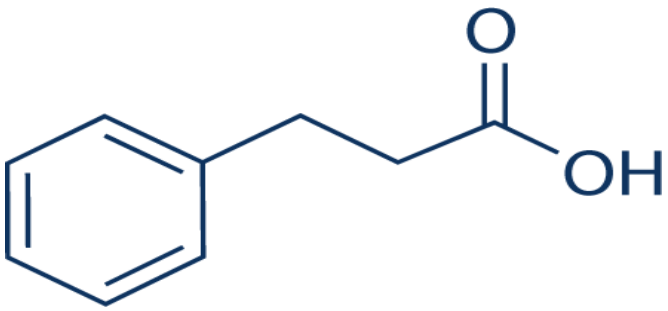
Quercetin is a naturally occurring flavonoid, a type of polyphenolic compound, found in various fruits, vegetables, and plants (Fig-9). It is known for its antioxidant and anti-inflammatory properties and has been the subject of numerous studies for its potential health benefits. Quercetin is a bioactive compound that may have a role in promoting human health due to its various biological activities[55].



[Fig-9: Structure of Quercetin]

8) Hydrosinnapic acid :

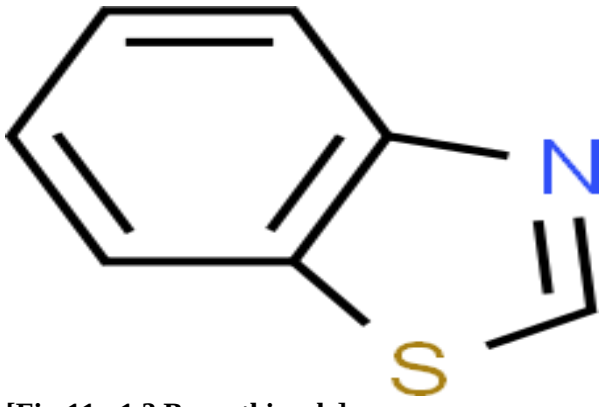
Hydrosinapic acid is a specific type of organic compound that belongs to a class of chemicals known as hydroxycinnamic acids (Fig-10). It is found in various plant species, including Brassica juncea, commonly known as brown mustard. Hydrosinapic acid is a phenolic compound and is related to other well-known hydroxycinnamic acids, such as ferulic acid and p-coumaric acid. Hydrosinapic acid, along with other hydroxycinnamic acids, acts as an antioxidant. Antioxidants help protect plants from damage caused by free radicals and oxidative stress. In humans, antioxidants can also help neutralize harmful free radicals, which are implicated in various health conditions,including aging and certain diseases[56].



[Fig-10: Hydrocynnamic acid]

9) 1,3 Benzothiazole :

1,3-benzothiazole is a chemical compound with a molecular structure consisting of a benzene ring fused to a thiazole ring (Fig-11). Thiazoles are a class of organic compounds containing both sulfur and nitrogen in a five-membered ring. This compound is a volatile organic compound that contributes to the characteristic aroma and flavor of brown mustard seeds (Brassica juncea). The role of 1,3-benzothiazole in brown mustard seeds is primarily related to flavor and aroma. It is one of the volatile components in the essential oil of mustard seeds, which gives mustard its distinctive pungent and spicy odor. The flavor and aroma of brown mustard are due to the presence of various volatile compounds, including 1,3-benzothiazole and allyl isothiocyanate [57].



[Fig-11 : 1,3 Benzothiazole]

CONCLUSION

Brassica juncea, *Sinapis alba*, and *Brassica nigra* demonstrate a diverse array of medicinal attributes encompassing antioxidant, anti-inflammatory, antimicrobial, and anticancer effects, among others. These therapeutic properties are linked to the presence of bioactive compounds like glucosinolates, phenolic compounds, essential oils, and specific phytochemicals. These components have been extensively studied for their potential health advantages. With a rich history of culinary and traditional uses, these mustard species play a significant role in both traditional medicine and cuisine. Recognizing their cultural importance provides insight into their broader significance. Additionally, the review highlights potential avenues for further research, emphasizing the need to delve into specific bioactive compounds, conduct clinical trials, and optimize extraction methods to fully understand and harness the medicinal potentialof these mustard species.

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