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Roll of Spices in Controlling Microbial Infection and in Modulation of the Immune System

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Abstract: ***Nature provided us with different products like fruits, flowers, vegetables, spices, herbs and so on. People utilize them since ancient times. Among them spices play key role in the lives of people and are used in rituals and in traditional medicines, beside using as food additives, preservatives and flavoring agents. People use spices to cure various infectious diseases like cancer, diabetes, viral infection, bacterial infection, fungal infection. At present, entire world is combating the coronavirus disease by utilizing different means. Scientific communities are trying to develop vaccines. Numerous evidences suggested that some common spices have the ability to reduce the severity of SARS-CoV-2 (severe acute respiratory syndrome – coronavirus). One of the main factor to prevent the infection is to boost the immunity power, which is possible by using the spices in our diet chart. Spices also possess potent antioxidant and anti-inflammatory properties. This study discusses how the spices and their components act as anti-inflammatory agents and prevent infection. The review work is done to find out different beneficial activities of spices, identify the phytochemicals that are responsible for their activities. Aim of this review is to acquaint researchers and international communities with the functions of spices and their bioactive components which are responsible in minimizing the infectivity rate and how the spices are controlling the immune system in combating the diseases.***
Keywords: SARS-CoV-2, spices, antioxidant, anti-inflammatory properties, Nrf2

I. INTRODUCTION

Mother Nature has bestowed us with various medicinal plants and it's products. The word spice comes from Old French word "espice". Use of natural products such as plant parts (fruits, leaves, bark, root, twig, stem and sap) as medicines, not only reliable or cost effective but also show least side effects. They are widely used for treating several chronic diseases, including cough, fever, asthma, diarrhea, indigestion and skin diseases [1]. Among which SARS-CoV-2 is most important contagious disease. Millions of people throughout the world are affected by this virus. As per update given by WHO on January 2021, worldwide total number of cases was 88,387,352 with 1,919,204 deaths [2].

It has become worldwide concern and so WHO declared this as pandemic. SARS-CoV-2 belongs to the members of beta-coronavirus, family Coronaviridae [3]. They are enveloped viruses having non-segmented, positive-stranded RNA genome [3]. CoVs enter the host cells via interaction between S-protein expressed on the surface of the virus and angiotensin-converting enzyme 2 receptor (ACE -2) present on the host cell surface [4]. Main symptoms of coronavirus (CoVs) are fever, dry cough, respiratory distress, shortness of breath, malaise, diarrhea and sneezing. But as the viral strain is modifying itself to escape the human's immune system, its symptoms are also changing. Therefore scientists are facing a challenging situation in developing vaccines. Because of its variation in structure, they gain the ability to attack different aged people from elderly to children. Co-morbid patients such as diabetes, cerebral infarction, chronic bronchitis, hypertension, cardiovascular disease, cancer, Parkinson's disease have higher chance of getting infected [5], [6], [7].

Spices and its components have shown to possess antioxidant and anti-inflammatory properties, which are used to treat chronic diseases. These compounds possess their antioxidant activity via different mechanisms which includes activation of nuclear factor (erythroid-derived 2)-like 2 (Nrf2) directly or indirectly [8] and all of them are found to be TRP (transient receptor potential) protagonist [9]. Biochemical molecules known as phytochemicals includes flavonoids, phenolic compounds, tannins, alkaloids and many more are found in spices [1]. SARS-CoV-2 outbreak led to devastating situation as we don't know specific treatment of CoV till date.

Research work showed that increased immunity lessen the severity of the infection. So to boost up the immune system, spices play a key role. This review canvasses about some Indian spices like black pepper, cinnamon, clove, turmeric, coriander, cumin, tamarind and asafetida, which are known as immunity boosters [10]. More explorations need to be done to identify the spices which can inhibit microbes from causing infectious and contagious diseases by using various mechanisms.

II. RELATION BETWEEN FOODS AND NRF2 AND TRPS

There are three different phases of COVID-19 infection – i. in this phase infection lasts for 1-2 weeks, ii. in next phase cytokine storm takes place along with oxidative stress storm and iii. then recovery phase which lasts for few months. Study proved that spices functions differently in different phases to combat the infection and to reduce this immune storm [9]. Further it is noted that biochemical compounds of spices have the ability to activate Nrf2 [11], [12]. Depending on the availability of spices, COVID-19 death rates varies among the countries. This is might be because of Nrf2 interaction with the spices which varies from place to place, and reduces the severity of infection [13], [14], [15]. Function of Nrf2 is to rebalance the oxidative stress [9]. Contrarily, as the balance between oxidant and antioxidant is difficult to obtain, many Nrf2 medicines were found to be toxic [9]. The TRP vanilloid 1 (TRPV1) and ankyrin 1 (TRPA1) belong to TRP superfamily. They are structurally correlated and nonselective cation channels [9]. To elicit symptoms of COVID-19 like vomiting, diarrhoea, cough, nasal obstruction, pain and sudden loss of smell and taste, TRPA1 and TRPV1 elevate sensory or vagal nerve discharges [16]. Reports confirmed that functions of TRPA1 and TRPV1 can be triggered by not all, Nrf2 interacting spices [16].

III. SPICES OF MEDICINAL VALUES

A. *Black Pepper (Piper nigrum L.)*

Black pepper is famous as the king of spices [1], [17]. It belongs to family Piperaceae [3]. It is found in India, Sumatra, Indonesia regions [18-20]. Studies showed that Black pepper has a dynamic activity like antimicrobial activity against *Escherichia coli*, *Pseudomonas aeurogenosa*, *Staphylococcus aureus*, *Aspergillus niger*, *Fusarium ox-ysporum*, *Aspergillus flavus* and *Mycobacterium tuberculosis* [21]. It also helps in stimulation of circulatory system. Piperine, alkaloid of black pepper has 1-peperoyl piperidine, which possess antihypertensive, anti-Alzheimer's, anti-inflammatory, antioxidant, antipyretic, antiasthmatic, antimicrobial, antitumor and many more properties [22]. Antioxidant capacity of pepper phenolic amides shown to be higher to the synthetic moieties Butylated hydroxytoluene (BHT) and Butylated hydroxyanisole (BHA) [23].

Experimental studies on evaluating the antiviral activity of chloroform and methanolic extracts of black pepper against human parainfluenza virus and vesicular stomatitis virus (an enteric virus) showed that antiviral activity in chloroform is higher because of having higher amount of alkaloids [24]. Another study showed that biochemical compound, piperine has the ability to inhibit methyltransferase of Dengue virus and VP35 of Ebola virus when compared to antiviral Ribavirin [25]. Another data depicts that consumption of black pepper in diet routinely may be helpful in preventing coronavirus [26]. Activity of black pepper as anti-inflammatory agent has been described in table 1.

B. *Turmeric (Curcuma Longa)*

Turmeric belongs to Zingiberaceae family. Since ancient times turmeric has been used in many rituals and in many traditional medicines as well. Turmeric is known as “Indian saffron” because of its brilliant yellow colour [36]. It is reported that for the treatment of various respiratory conditions, liver disorders, anorexia, rheumatism, diabetic wounds, runny nose, cough, and sinusitis, diseases associated with abdominal pain, turmeric is used [37], [38]. Sometimes, turmeric mixed with warm milk is consumed to treat intestinal disorders, colds and sore throats [36]. Many biochemical compounds present in turmeric act as antiviral, anti-cancer, anti-atherosclerotic, anti-depressant, anti-diabetic, anti-arthritic agents, among them most notable one is curcumin. Curcumin is signified as “Golden nutraceutical” because of its pharmacological activities like anti-cancer (breast, colorectal, ovarian, cervical, pancreatic, prostrate etc), anti-viral, illustrated in table 2, anti-fungal and many more [39], [40]. Hexane and methanol extracts of turmeric elicit antibacterial activities against *Vibrio harveyi, V. alginolyticus, V. vulnificus, Streptococcus agalactiae, Staph. aureus, Staph. intermedius, Staph. epidermidis, Edwardsiella tarda, V. parahaemolyticus, V. cholerae, Aeromonas hydrophila* and *Bacillus subtilis* [41]. Further the role of turmeric in anti-inflammation is de-scribed in the table 1.

TABLE 2: Antiviral properties of curcumin and its mechanism of action

SL. NO.	VIRUS	MECHANISM of ACTION	REFERENCES
1	SARS coronavirus	Inhibits replication and protease activity	50
2	Herpes virus	Inhibits gene expression	51
3	Hepatitis B virus	Inhibits replication and cccDNA	52
4	Hepatitis C virus	Entry inhibitor	53
5	Human immunodeficiency virus	Impedes protease, integrase and Tat protein function	54

6	Human papilloma virus	Suppress gene expression	55
7	Respiratory syncytial virus	Entry inhibitor replication and budding inhibition	56
8	Chickun gunya virus	Blocks entry of the virus	57
9	Dengue virus	Entry inhibitor, Particle production, Inhibition	58
10	Zikavirus	Blocks entry of the virus	57
11	Influenza A virus	Prevents virus uptake, replication and particle production	59

C. Clove (Syzygium aromaticum)

Clove belongs to the family Mirtaceae, is known for its action against oral bacteria [3]. Native of Indonesia, but it is cultivated across the world. Cloves act as larvicidal agent to resist dengue, acts as an analgesic for joint pains, toothache and other serious health problem in tropical countries [60], [61]. One of the important bioactive com-pound of clove is eugenol which exhibits broad antimicrobial activities ranging from *Escherichia coli, Bacillus subtilis, Candida albicans, Salmonella typhimurium, Staphylococcus aureus to Rhizopus nigricans* and *Aspergillus niger* [3], [62]. According to World Health Organization (WHO), humans can uptake clove daily 2.5mg/kg body weight [63]. Ethanolic and aqueous extracts of clove have antioxidant activity, hydrogen donating ability, metal chelating ability and scavenging of free radicals, hydrogen peroxide and superoxide [64]. Reports suggested that eugeniin, extract of *Syzygium aromaticum* possess inhibitory action against the HSV-1 DNA polymerase [3].

D. Coriander (Coriandrum Sativum)

Coriander belongs to Apiaceae/Umbelliferae family [65]. Geographical distribution of coriander is from Turkey, Italy, Russia, India, Morocco, Bulgaria, Central and Eastern Europe, China to Western Asia and Mediterranean regions [66]. Different parts of coriander exhibit antioxidant activity, sedative, anti-microbial activity, anti-convulsantactivity, diuretic, hypnotic activity, hepatoprotective, anti-diabetic, anti-helmintic activity and anti-mutagenic activity [67], [68]. Seed oil of coriander exhibits antimicrobial activity against *Staphylococcus aureus and Gram negative bacterial strains including Escherichia coli, Klebsiella pneumoniae, Salmonella typhimurium* and *Pseudomonas aeruginosa* and two clinical multidrug-resistant *Acinetobacter baumannii* [69]. Reports suggested that coriander extracts inhibit Human Immuno-deficiency Virus (HIV) by interfering it's replication cycle, dengue viruses and Middle East Respiratory Syndrome (MERS) coronaviruses [66]. Extracts of ethanol, methanol, acetone, chloroform, hexane and petroleum ether showed activity against infectious diseases such as *Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus* and *Klebsiella pneumonia* fungus like *Aspergillus niger, Candida albicans, Candida kefyr* and *Candida tropicalis* [70]. Extracts of *Coriandrum sativum* are used to induce potent anti-inflammatory effects both in vitro and in vivo as well, illustrated in table 1.

E. Tamarind (Tamarindus Indica L.)

It belongs to group of the Fabaceae, sub-family Caesalpinioideae [74]. The major tamarind producing countries are in the Asian countries India and Thailand, but also in Bangladesh, Sri Lanka, Thailand and Indonesia [75]. Different parts of tamarind can be used for treatment of several chronic diseases [76]. The seed kernels or tamarind seed coat extract (TSCE) possess high antioxidant activity. It prevents anemia, regulates glutathione levels and reduces lipid peroxidation [77]. Extracts of tamarind leaves showed antioxidant activity in the liver. Hypolipemic activity was noticed from tamarind fruit extract for the treatment of hypercholesterolemic hamsters, besides anti-oxidant properties [78]. Extracts from tamarind flowers showed antibacterial activity against *Staphylococcus aureus, Bacillus subtilis, Escherichia coli* and *Pseudomonas aeruginosa* [79], [80]; against fungal cultures of *Aspergillus niger* and *Candida albicans* [75], [81]; anti-viral activities against watermelon mosaic viruses, cow pea mosaic viruses and tobacco mosaic virus [81]; exhibit anti-nematodal activity, moluscicidal activity, anti-diabetic activity [82], cytotoxic activity [80]. Tamarind also known as Imli known for its mutagenic, antihepatotoxic, cholesterolemic, anti-inflammatory properties [83]. Tamarind acting as an anti-inflammatory agents against diseases shown in table 1.

F. Cumin (Cuminum Cyminum)

Cumin belongs to Apiaceae family. Geographical distribution of cumin is from East Meditaranian to South Asia, Central Asia to Northern India, mountainous regions of North India, Syria, Turkey, Iran, and Saudi Arabia [87]. There is another type of cumin – Black cumin (Nigella sativa). Black cumin is widely used as anti-inflammatory, hepatoprotective, anti-diabetic, hypotensive agents and so on [88]. Pharmacological properties of it includes hypotensive, antinociceptive, uricosuric, choleretic, antifertility, antidiabetic, antihistaminic, anti-oxidant, anti-inflammatory, anti-microbial, anti-tumor and immunomodulatory effects [89].

It's aqueous and oil extracts possess antioxidant, anti-inflammatory, anticancer, analgesic, antimicrobial activities, table 1 [90], [91]. Extracts of cumin possess antimicrobial effects against *Aspergillus spp., Penicillium spp., Saccharomyces, Candida spp., Escherichia coli* [92] and antiviral activity against HSV-1[93]. Apart from these, used in the treatment of bronchial asthma and eczema [94], antihelminthic [95], antinematodal [96], antischistosomal [97], antimicrobial [98], [99], [100] and antiviral [101]. Cuminaldehyde inhibit the fibrillation of alpha-synuclein (α-SN), Parkinson's disease [102].

G. Cinnamon (Cinnamomum sp.)

Cinnamon belongs to the family Lauraceae. Geographically it is distributed in the tropical countries like India, Sri Lanka, Malabar, Caribbean, Sumatra, Myanmar, China, Caribbean, Central and South America and Africa [111]. Cinnamon bark oil, cinnamaldehyde and eugenol exhibit potent antibacterial effects against *Bacillus cereus, Campylobacter jejuni, Enterococcus faecalis, Escherichia coli, Penicillium roqueforti, Staphylococcus aureus, Listeria monocytogenes, Streptococcus pneumoniae, Haemophilus influenzae, Pseudomonas aeruginosa, Pediococcus halophilus, Salmonella choleraesuis, S. enterica, Mucor plumbeus, Aspergillus flavus, Eurotium sp., S. pyogenes* and *Yersinia enterocolitica* [112], [113], [114], [115]. Study showed that cinnamon has anti-inflammatory, antifungal, antiviral, antioxidant, antitumor, cardiovascular, cholesterol lowering, and immunomodulatory effects, illustrated in table 1. Reports suggested that cinnamon may act as an insulin mimetic, to potentiate insulin activity or to stimulate cellular glucose metabolism [116].

In accordance with, the phagocytic index, serum immunoglobulin levels increased due to higher dose (100 mg/kg) of cinnamon. Whereas low dose (10mg/kg) leads to increase in serum immunoglobulin levels only. Hence, higher dose increases both the humoral and cell-mediated immunity and low dose increases humoral immunity only [3]. Reports revealed that hydroalcoholic extracts of cinnamon was effective in reducing the viral load of HSV-1 by preventing the attachment of viral particles onto the cells [3].

H. Asafoetida (Ferula asafetida)

It belongs to kingdom Plantae, class Magnoliopsida, family Umbelliferae [124]. Geographically asafoetida is ex-tended from central Asia, eastern Iran to Afghanistan [125]. Pharmacological studies showed that it possesses anti-fungal, antioxidant, antidiabetic, antispasmodic, anticancer, hypotensive etc in oleo-gum-resin part [126]. It's secondary metabolite sesquiterpene coumarin acts as an important compound in synthesizing new drug against Influ-enza A (H1N1) viral infection. It manifests antimicrobial activities against *Escherichia coli, Shigella flexneri, Bacillus megaterium, Staphylococcus epidermidis, Vibrio cholera, Micrococcus leuteus* [1] and antiviral activities against type 1 or 2 herpes virus, strains of influenza virus and rhinoviruses [127]. Asafoetida controls liver and breast cancer by regulating inflammatory responses which is illustrated in the table 1.

TABLE 1: Role of spices in anti-inflammation

SPICES	COMPOUND USE/FORM OF USE	DISEASE	MECHANISM	REFERENCES
Black Pepper	Extract	Asthma	↓ IL-1β, ↓ TNF-α, ↓ IL-4, ↓ RORγt, ↓IgE, ↓ IL-17A	27
		AR	↓ E-cadherin, ↑ HO-1, ↑ Nrf2	28
			↓ p-STAT3, ↓ IL-6, ↓ TNF-α, ↓ NF-κB p65, ↓ IL-1β	29
	Pipernigramides	Edema	↓ TNF-α, ↓ IL-1β, ↓ IL-6, ↓ PGE2, ↓ p-IKKβ	30
			↓ NO, ↓ neutrophils infiltration	
	Piperine	Lung metastasis	↓ tumor nodule formation, ↑ survival rate, ↓ SA, ↓ GGT	31
		Bacterial sepsis	↓ IL-1β, ↓ HMGB1, ↓ p-AMPK	32
			↓ IL-1β release	
		AP	↓ MPO, ↓ TNF-α, ↓ IL-1β, ↓ IL-6, ↓ p-ERK1/2, ↓ p-p38, ↓ p-JNK	33

		Lupus nephritis	↓p-AMPK, ↓ IL-1β, ↓ HMGB1, ↓ pro-caspase-1	34
			↓ NLRP3 inflammasome activitation	34
	Chabamide	Inflammation	↑ HO-1, ↑ Nrf2, ↓ iNOS	35
Turmeric	Curcumin	PIVP	↓ IL6, ↓ TNF-α, ↓ MCP-1, ↓ NF-κB, ↑ IκBα, ↑ HO-1	42
		Cystic fibrosis	↑ CFTR, ↓ cox-2, ↓ PGE2, ↓ IL-8	43
		Diabetes	↓ NF-κB, ↓ TNF-α, ↓ IL-1β, ↓ IL-6 ↓ NO, ↓ PGE2, ↓ cox-2	44
		ALI	↓ TNF-α, ↓ IL-8, ↓ MIF	45
		Asthma	↓ NICD1, ↓ Notch 1/2 receptors	46
		Cerebral I/R injury	↓ IL-1β, ↓ IL-8, ↑ p-JAK2, ↑ p-STAT3	47
	ATM	Psoriasis	↓ NF-κB, ↓ cox-2, ↓ p-p38 MAPK, ↓ TNF-α, ↓ IL-6, ↓ mRNA synthesis of IL-17, -22, and -23	48
	MTrPP	Ulcer	↓ TNF-α, ↓ IL-8, ↓ NF-κB, ↓ p-p38, ↓ MMP-9, ↓ cox-1 and -2	49
Coriander	Extract	Inflammation	↓ pro-IL-1β, ↓ PGE2, ↓ p-MAPK, ↓ NF-κB p65, ↓ cox-2, ↓ NO, ↓ iNOS	71
		CD	↓ IL-1, ↓ IL-4, ↓ IL-13, ↓ TNF-α, ↓ IFN-γ, ↓ IgE, ↑ GSH, ↑ HO-1	72
		Arthritis	↓ IL-1β, ↓ IL-6, ↓ TNF-R1	73
Tamarind	Extract	Pulmonary inflammation and fibrosis	↓ ROS, ↓ LPO, ↓ PCC, ↓ NF-κB, ↓ p38α MAPK, ↓ NOX4, ↓ cox-2, ↑ HO-1, ↑ SOD2, ↑ catalase, ↑ GST, ↑ GSH, ↑ GPx	84
		Arthritis	↓ IL-1β, ↓ IL-6, ↓ IL-23, ↓ TNF-α, ↓ cox-2, ↓ MMP	85
	Xyloglucan	Ulcerative colitis	↓ IL-1β , ↓ IL-6, ↓ TLR4, ↓ NF-κB	86
Cumin	Seed	Hypertension	↓ mRNA expression of IL-6, Bax, and TNF-α, ↑ mRNA of expression TRX1, TRXR1, eNOS, and Bcl-2	103
		Gastric ulcer	↓ TNF-α, ↓ MDA, ↑ GSH, ↑ catalase, ↑ ATPase activity	104
Black cumin	Extract	Lung inflammation	↓ TGF-β1, ↓ IFN-γ, ↓ PGE2, ↑ IL-4, ↑ catalase, ↑ SOD, ↓ MDA, ↑ thiol	105
		Diabetes	↓ mRNA expression of VCAM-1 and LOX-1, ↑ mRNA expression of eNOS,	106
		-	↓ MDA, ↓ NO, ↓ IL-6, ↑ thiol, ↑ SOD, ↑ catalase, ↓ AST, ↓ ALT, ↓ ALP, ↑ serum protein, ↑ albumin	107
	Oil	Low-grade inflammation	↓ IL-1β, ↓ MCP-1, ↓ gene expression of DNMT3A and HDAC1	108
		Allergic asthma	↓ IL-4, ↓ NO	109
	TQ	AD	↓ TLR-2, ↓ TLR-4, ↓ TNF-α, ↓ MyD88, ↓ IL-1β, ↓ IRF-3, ↓ NF-κB	110
Cinnamon	TCA	OA	↓ mRNA expression of MMP-1, -3 and -13, ↓ mRNA expression of ADAMTS-4 and -5, ↑ p-	117

			IκBα, ↓ NF-κB, ↓ IκBα, ↓ p-JNK 1/2, ↓ p-p38	
	TCA	-	↓ NO, ↓ iNOS	118
	TCA	Neuroinflam-mation	↓ NO, ↓ iNOS, ↓ cox-2, ↓ IL-1β, ↓ IκBα, ↓ NF-κB	119
	Oil	Skin disease	↓ MCP-1, ↓ MIG, ↓ IP- 10, ↓ IL-8, ↓ VCAM-1, ↓ M-CSF, ↓ PAI-1, ↓ ICAM-1, ↓ EFGR, ↓ MMP-1, ↓ TIMP-1, ↓ TIMP-2	120
	Extract	Inflammation	↓ mRNA expression of TNF-α, ↓ p-p38, ↓ IκBα degradation, ↓ p-ERK 1/2, ↓ p-JNK, ↓ TNF-α, ↓ IL-6	121
			↑ IL-2, ↓ IL-4, ↓ IFN-γ, ↓ p-ERK1/2, ↓ p-p38, ↓ p-STAT4, ↓ p-JNK	122
	BCA, HCA	-	↓ IFN-γ, ↓ IL-2Rα, ↓ IgM, ↓ AFC response	123
Asafoetida	Oil	Liver cancer	↓ NF-κB, ↓ TGF-β1, ↑ caspase-3, ↑ TNF-α	128
	Resin	Breast cancer	↓ LOX	129
			↓ cyt-P450, ↓ cyt b5, ↑ catalase, ↑ GSH, ↑ GST, ↑ SOD, ↓ TBARS, ↑ DT-diaphorase	130

1) *Abbreviations:* AD: Alzheimer‟s disease, ADAMTS: a disintegrin and metalloproteinase with thrombospondin motifs, ALP: Alkaline phosphatase, ALT: Alanine aminotransferase, AMPK: Adenosine monophosphate-activated protein kinase, AST: Aspartate aminotransferase, ATM: Aromatic-turmerone, Bax: B-cell lymphoma 2 (Bcl-2)-associated X protein, BCA : 2´-benzoxycinnamaldehyde, Bcl-2: B-cell lymphoma 2, CFTR: Cystic fibrosis transmembrane conductance regulator, DNMT3A: DNA methyltransferase 3A, EFGR: Epidermal growth factor receptor, eNOS: endothelial nitric oxide, ERK: Extracellular signal-regulated kinase, GGT: Gamma glutamyl transpeptidase, GM-CSF: Granulocyte macrophage colony-stimulating factor, GPx: glutathione peroxidase, GSH: Glutathione, GST: Glutathione S-transferase, HCA : 2´-hydroxycinnamaldehyde, HDAC1: Histone Deacetylase 1, HO-1: Heme oxygenase-1, HMGB1: High mobility group box-1 protein, ICAM-1- intercellular cell adhesion molecule-1, IFN: Interferon, iNOS: Inducible nitric oxide synthase, IP-10: Interferon-inducible protein 10, JAK: Janus kinase 2, JNK: c-Jun N-terminal kinase, LOX: Lipoxygenase, LPO: Lipid peroxidation, MAPK: Mitogen-activated protein kinase, MDA: Malondialdehyde, MCP: Monocyte chemoattractant protein, M-CSF: Macrophage colony-stimulating factor, MIG: Monokine induced by gamma, MIP: Macrophage inflammatory protein, MMP: matrix metalloproteinases, MPO: Myeloperoxidase, MTrPP: Modified pectin polysaccharide from turmeric, NICD: Notch intracellular domain, NLRP3: Nucleotide oligomerization domain (NOD)-like receptor protein 3, NO: Nitric oxide, NOX4: Nicotinamide adenine dinucleotide phosphate (NADPH) oxidase 4, Nrf2: Nuclear factor erythroid 2-related factor 2, OA: Osteoarthritis, PAI-1: Plasminogen activator inhibitor-1, PCC: Protein carbonyl content, PIVP: Primary influenza viral pneumonia, PGE2: prostaglandin E2, ROS: Reactive oxygen species, RORγt: Retinoic acid-related orphan receptor-γt, SA: serum sialic acid, SOD: Superoxide dismutase, STAT: Signal transducer and activator of transcription, TBARS: Thiobarbituric acid reactive substances, TCA: Trans cinnamaldehyde, TGF-β : Transforming growth factor-β, TIMP-1: Tissue inhibitor of metalloproteinase, TLRs: Toll-like receptors, TQ : Thymoquinone, TRX1: Thioredoxin 1, TRXR1: Thioredoxin reductase 1, VCAM-1: Vascular cell adhesion protein 1

IV. CONCLUSIONS

The modulation by Nrf2 of TRPA1/V1 is still not clear, so more investigation need to be done on this area. In pre-sent pandemic situation more immune boosting is required to beat the COVID-19 infection. From the above study it can be concluded that spices like black pepper, turmeric, clove etc possess antioxidant, immunity boosting proper-ties, anti-inflammatory activities and play vital role against many bacteria, fungus, yeast and also viruses including SARS-COV-2. More data need to be explored about the biochemical compounds present in the Indian spices and their affectivity and mode of action against diseases.

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REFERENCES

[1] Singh S, Sharma S, Hameed S, Fatima Z. Antimicrobial potential of Indian spices. Biot Today, 6(1):65-8, 2016. doi: 10.5958/2322-0996.2016.00010.7.
[2] Kunnumakkara AB, Rana V, Parama D, Banik K, Girisa S, Sahu H, et al. COVID-19, cytokines, inflammation, and spices: how are they related? Life Sci, 119201, 2021. doi: 10.1016/j.lfs.2021.119201, PMID 33607159.
[3] Singh NA, Kumar P, Jyoti KN, Kumar N. Spices and herbs: potential antiviral preventives and immunity boosters during COVID-19. Phytother Res 1-13, 2021. doi: 10.1002/ptr.7019, PMID 33511704.
[4] Walls AC, Park YJ, Tortorici MA, Wall A, McGuire AT, Veesler D. Structure, function, and antigenicity of the SARS- CoV-2 spike glycoprotein. Cell, 181(2):281-292.e6, 2020. doi: 10.1016/j.cell.2020.02.058, PMID 32155444.
[5] Deng SQ, Peng HJ. Characteristics of and public health responses to the coronavirus disease 2019 outbreak in China. J Clin Med, 9(2):575, 2020. doi: 10.3390/jcm9020575, PMID 32093211.
[6] Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. N Engl J Med, 382(18):1708-20, 2020. doi: 10.1056/NEJMoa2002032, PMID 32109013.
[7] Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. Lancet, 395(10223):497-506, 2020. doi: 10.1016/S0140-6736(20)30183-5.
[8] Bousquet J, Cristol JP, Czarlewski W, Anto JM, Martineau A, Haahtela T, et al. Nrf2-interacting nutrients and COVID-19: time for research to develop adaptation strategies. Clin Transl Allergy, 10(1):58, 2020. doi: 10.1186/s13601-020-00362-7, PMID 33292691.
[9] Bousquet J, Czarlewski W, Zuberbier T, Mullol J, Blain H, Cristol JP, et al. Spices to control COVID-19 symptoms: yes, but not only… int. Int Arch Allergy Immunol, 182(6):489-95, 2021. doi: 10.1159/000513538, PMID 33352565.
[10] Shrivastava R. Immunity boosters: solutions from nature – herbs and spices. J Renal Nutr Metab, 6(2):35-7, 2020. doi: 10.4103/jrnm.jrnm_20_20.
[11] Jiménez-Osorio AS, González-Reyes S, Pedraza-Chaverri J. Natural Nrf2 activators in diabetes. Clin Chim Acta, 448:182-92, 2015. doi: 10.1016/j.cca.2015.07.009, PMID 26165427.
[12] Pall ML, Levine S. Nrf2, a master regulator of detoxification and also antioxidant, anti-inflammatory and other cytoprotective mechanisms, is raised by health promoting factors. Sheng Li Xue Bao, 67(1):1-18, 2015. PMID 25672622.
[13] Bousquet J, Czarlewski W, Blain H, Zuberbier T, Anto J. Rapid response: why Germany's case fatality rate seems so low: is nutrition another possibility. BMJ, 369:m1395, 2020.
[14] Bousquet J, Anto JM, Iaccarino G, Czarlewski W, Haahtela T, Anto A, et al. Is diet partly responsible for differences in COVID-19 death rates between and within countries? Clin Transl Allergy, 10(1):16, 2020. doi: 10.1186/s13601-020-00323-0, PMID 32499909.
[15] Bousquet J, Anto JM, Czarlewski W, Haahtela T, Fonseca SC, Iaccarino G, et al. Cabbage and fermented vegetables: from death rate heterogeneity in countries to candidates for mitigation strategies of severe COVID-19. Allergy, 76(3):735-50, 2021. doi: 10.1111/all.14549, PMID 32762135.
[16] Talavera K, Startek JB, Alvarez-Collazo J, Boonen B, Alpizar YA, Sanchez A, et al. Mammalian transient receptor potential TRPA1 channels: from structure to disease. Physiol Rev, 100(2):725-803, 2020. doi: 10.1152/physrev.00005.2019, PMID 31670612.
[17] Sun J, Chu YF, Wu X, Hai Liu RH, Department of Food Science and Institute of Comparative and Environmental Toxicology, Stocking H, Cornell University. Antioxidant and antiproliferative activities of common fruits. J Agric Food Chem, 50(25):7449-54, 2002. doi: 10.1021/jf0207530, PMID 12452674.
[18] Majeed D, Prakash L. The medicinal uses of pepper. Int Pepper News, 1:23-31, 2000.
[19] Tainter D, Grenis A. Spices and seasonings: A food technology handbook. 2nd ed. Hoboken, NJ: Wiley. General & Introductory Food Science & Technology, 2001.
[20] Burdock G. Encyclopedia of food color additives. Boca Raton, FL: CRC Press Press; 1997.
[21] Rani S, SK, Saxena N, Udayshree. Antimicrobial activity of black Peper (Piper nigrum L.). Glob J Pharmacol, 7:087-90, 2013.
[22] Tiwari A, Mahadik KR, Gabhe SY. Piperine: A comprehensive review of methods of isolation, purification, and biological properties. Med Drug Discov, 7., 2020. doi: 10.1016/j.medidd.2020.100027, PMID 100027.
[23] Meghwal M, Goswami TK. Nutritional constituent of black pepper as medicinal molecules: a review; open access. 1;01(1):129, 2012. doi: 10.4172/scientificreports.129.
[24] Priya NC, Saravana K. Antiviral activities and cytotoxicity assay of seed extracts of Piper longum and Piper nigrum on human cell lines. Int J Pharm Sci Rev Res, 44(1):197-202, 2017.
[25] Nag A, Chowdhury RR. Piperine, an alkaloid of black pepper seeds can effectively inhibit the antiviral enzymes of Dengue and Ebola viruses, an in silico molecular docking study. Virus disease, 31(3):308-15, 2020. doi: 10.1007/s13337-020-00619-6, PMID 32904842.
[26] Rajagopal K, Byran G, Jupudi S, Vadivelan R. Activity of phytochemical constituents of black pepper, ginger, and garlic against coronavirus (COVID-19): an in silico approach. Int J Health Allied Sci, 9:S43-50, 2020.
[27] Bui TT, Piao CH, Song CH, Shin HS, Shon DH, Chai OH. Piper nigrum extract ameliorated allergic inflammation through inhibiting Th2/Th17 responses and mast cells activation. Cell Immunol, 322:64-73, 2017. doi: 10.1016/j.cellimm.2017.10.005, PMID 29066080.
[28] Bui TT, Fan Y, Piao CH, Van Nguyen TV, Shin DU, Jung SY, et al. Piper nigrum extract improves OVA-induced nasal epithelial barrier dysfunction via activating Nrf2/HO-1 signaling. Cell Immunol, 351:104035, 2020. doi: 10.1016/j.cellimm.2019.104035.
[29] Bui TT, Piao CH, Hyeon E, Fan Y, Van Nguyen T, Jung SY, et al. The protective role of Piper nigrum fruit extract in an ovalbumin-induced allergic rhinitis by targeting of NFκBp65 and STAT3 signalings. Biomed Pharmacother, 109:1915-23, 2019. doi: 10.1016/j.biopha.2018.11.073, PMID 30551446.
[30] Pei H, Xue L, Tang M, Tang H, Kuang S, Wang L, et al. Alkaloids from black pepper (Piper nigrum L.) exhibit anti-inflammatory activity in murine macrophages by inhibiting activation of NF-κB pathway. J Agric Food Chem, 68(8):2406-17, 2020. doi: 10.1021/acs.jafc.9b07754, PMID 32031370.
[31] Pradeep CR, Kuttan G. Effect of piperine on the inhibition of lung metastasis induced B16F-10 melanoma cells in mice. Clin Exp Metastasis, 19(8):703-8, 2002. doi: 10.1023/a:1021398601388, PMID 12553376.
[32] Liang YD, Bai WJ, Li CG, Xu LH, Wei HX, Pan H, et al. Piperine suppresses pyroptosis and interleukin-1β release upon ATP triggering and bacterial infection. Front Pharmacol, 7:390, 2016. doi: 10.3389/fphar.2016.00390, PMID 27812336.
[33] Bae GS, Kim MS, Jeong J, Lee HY, Park KC, Koo BS, et al. Piperine ameliorates the severity of cerulean induced acute pancreatitis by inhibiting the activation of mitogen activated protein kinases. Biochem Biophys Res Commun, 410(3):382-8, 2011. doi: 10.1016/j.bbrc.2011.05.136, PMID 21663734.

[34] Peng X, Yang T, Liu G, Liu H, Peng Y, He L. Piperine ameliorated lupus nephritis by targeting AMPK-mediated activation of NLRP3 inflammasome. Int Immunopharmacol, 65:448-57, 2018. doi: 10.1016/j.intimp.2018.10.025, PMID 30388519.
[35] Ngo QM, Tran PT, Tran MH, Kim JA, Rho SS, Lim CH, et al. Alkaloids from Piper nigrum exhibit anti-inflammatory activity via activating the Nrf2/HO-1 pathway. Phytother Res, 31(4):663-70, 2017. doi: 10.1002/ptr.5780, PMID 28185326.
[36] Prasad S, Aggarwal B, Bharat. Chapter 13. Turmeric, the golden spice: from traditional medicine to modern medicine. In: Herbal medicine: biomolecular and clinical aspects. 2nd ed. Boca Raton, (FL): CRC Press Press/Taylor & Francis; 2011.
[37] Araújo CC, Leon LL. Biological activities of Curcuma longa L. Mem Inst Oswaldo Cruz, 96(5):723-8, 2001. doi: 10.1590/s0074-02762001000500026, PMID 11500779.
[38] Aggarwal BB, Takada Y, Oommen OV. From chemoprevention to chemotherapy: common targets and common goals. Expert Opin Investig Drugs, 13(10):1327-38, 2004. doi: 10.1517/13543784.13.10.1327, PMID 15461561.
[39] Kunnumakkara AB, Sailo BL, Banik K, Harsha C, Prasad S, Gupta SC, et al. Chronic diseases, inflammation, and spices: how are they linked? J Transl Med, 16(1):14, 2018. doi: 10.1186/s12967-018-1381-2, PMID 29370858.
[40] Shabnam B, Harsha C, Thakur KK, Khatoon E, Kunnumakkara AB. Curcumin: A potential molecule for the prevention and treatment of inflammatory diseases. The Chemistry and Bioactive Components of Turmeric. Royal Society of Chemistry, pp. 150-71, 2020.
[41] Moghadamtousi SZ, Kadir HA, Hassandarvish P, Tajik H, Abubakar S, Zandi K. A review on antibacterial, antiviral, and antifungal activity of curcumin. BioMed Res Int, 12 pages, 2014. doi: 10.1155/2014/186864, PMID 24877064.
[42] Han S, Xu J, Guo X, Huang M. Curcumin ameliorates severe influenza pneumonia via attenuating lung injury and regulating macrophage cytokines production. Clin Exp Pharmacol Physiol, 45(1):84-93, 2018. doi: 10.1111/1440-1681.12848, PMID 28853207.
[43] Dong ZW, Chen J, Ruan YC, Zhou T, Chen Y, Chen Y, et al. CFTR-regulated MAPK/NF-κB signaling in pulmonary inflammation in thermal inhalation injury [sci rep:15946]. Sci Rep, 5:15946, 2015. doi: 10.1038/srep15946, PMID 26515683.
[44] Zhang F, Yang F, Zhao H, An Y. Curcumin alleviates lung injury in diabetic rats by inhibiting nuclear factor-κB pathway. Clin Exp Pharmacol Physiol, 42(9):956-63, 2015. doi: 10.1111/1440-1681.12438, PMID 26111829.
[45] Xiao X, Yang M, Sun D, Sun S. Curcumin protects against sepsis-induced acute lung injury in rats. J Surg Res, 176(1):e31-9, 2012. doi: 10.1016/j.jss.2011.11.1032, PMID 22520056.
[46] Chong L, Zhang W, Nie Y, Yu G, Liu L, Lin L, et al. Protective effect of curcumin on acute airway inflammation of allergic asthma in mice through Notch1-GATA3 signaling pathway. Inflammation, 37(5):1476-85, 2014. doi: 10.1007/s10753-014-9873-6, PMID 24706026.
[47] Li L, Li H, Li M. Curcumin protects against cerebral ischemia-reperfusion injury by activating JAK2/STAT3 signaling pathway in rats. Int J Clin Exp Med, 8(9):14985-91, 2015. PMID 26628981.
[48] Li YL, Du ZY, Li PH, Yan L, Zhou W, Tang YD, et al. Aromatic-turmerone ameliorates imiquimod-induced psoriasis-like inflammation of BALB/c mice. Int Immunopharmacol, 2018;64:319-25, 2018. doi: 10.1016/j.intimp.2018.09.015, PMID 30243067.
[49] Rajagopal HM, Manjegowda SB, Serkad C, Dharmesh SM. A modified pectic polysaccharide from turmeric (Curcuma longa) with antiulcer effects via anti-secretary, mucoprotective and IL-10 mediated anti-inflammatory mechanisms. Int J Biol Macromol, 118(A):864-80, 2018. doi: 10.1016/j.ijbiomac.2018.06.053, PMID 29924982.
[50] Wen CC, Kuo YH, Jan JT, Liang PH, Wang SY, Liu HG, et al. Specific plant terpenoids and lignoids possess potent antiviral activities against severe acute respiratory syndrome coronavirus. J Med Chem, 50(17):4087-95, 2007. doi: 10.1021/jm070295s, PMID 17663539.
[51] Kutluay SB, Doroghazi J, Roemer ME, Triezenberg SJ. Curcumin inhibits herpes simplex virus immediate-early gene expression by a mechanism independent of p300/CBP histone acetyltransferase activity. Virology, 373(2):239-47, 2008. doi: 10.1016/j.virol.2007.11.028, PMID 18191976.
[52] Wei ZQ, Zhang YH, Ke CZ, Chen HX, Ren P, He YL, et al. Curcumin inhibits hepatitis B virus infection by down-regulating cccDNA bound histone acetylation. World J Gastroenterol, 23(34):6252-60, 2017. doi: 10.3748/wjg.v23.i34.6252, PMID 28974891.
[53] Anggakusuma, Colpitts CC, Schang LM, Rachmawati H, Frentzen A, Pfaender S, et al. Turmeric curcumin inhibits entry of all hepatitis C virus genotypes into human liver cells. Gut, 63(7):1137-49, 2014. doi: 10.1136/gutjnl-2012-304299, PMID 23903236.
[54] Ali A, Banerjea AC. Curcumin inhibits HIV-1 by promoting Tat protein degradation. Sci Rep 2016;6(1):27539. doi: 10.1038/srep27539, PMID 27283735.
[55] Mishra A, Kumar R, Tyagi A, Kohaar I, Hedau S, Bharti AC, et al. Curcumin modulates cellular AP-1, NF-kB, and HPV16 E6 proteins in oral cancer. Ecancer medical science, 9:525, 2015. doi: 10.3332/ecancer.2015.525, PMID 25932049.
[56] Yang XX, Li CM, Li YF, Wang J, Huang CZ. Synergistic antiviral effect of curcumin functionalized graphene oxide against respiratory syncytial virus infection. Nanoscale, 9(41):16086-92, 2017. doi: 10.1039/c7nr06520e, PMID 29034936.
[57] Mounce BC, Cesaro T, Carrau L, Vallet T, Vignuzzi M. Curcumin inhibits Zika and Chikungunya virus infection by inhibiting cell binding. Antiviral Res, 142:148-57, 2017. doi: 10.1016/j.antiviral.2017.03.014, PMID 28343845.
[58] Padilla-S L, Rodríguez A, Gonzales MM, Gallego-G JC, Castaño-O JC. Inhibitory effects of curcumin on dengue virus type 2-infected cells in vitro. Arch Virol, 159(3):573-9, 2014. doi: 10.1007/s00705-013-1849-6, PMID 24081825.
[59] Dai J, Gu L, Su Y, Wang Q, Zhao Y, Chen X, et al. Inhibition of curcumin on influenza A virus infection and influenzal pneumonia via oxidative stress, TLR2/4, p38/JNK MAPK and NF-κB pathways. Int Immunopharmacol, 54:177-87, 2018. doi: 10.1016/j.intimp.2017.11.009, PMID 29153953.
[60] Cortés-Rojas DF, de Souza CR, Oliveira WP. Clove (Syzygium aromaticum): a precious spice. Asian Pac J Trop Biomed, 4(2):90-6, 2014. doi: 10.1016/S2221-1691(14)60215-X, PMID 25182278.
[61] Hamdy E. Healthcare T. PDR for herbal medicines. 4th ed. Montvale: Thomson Healthcare. ISBN: 1-56363-361-2; 2007.
[62] AMES, . IMOEB, . EAAEK. Nutritive value of clove (Syzygium aromaticum) and detection of antimicrobial effect of its bud oil [research article]. Res J Microbiol, 2(3):266-71, 2007. doi: 10.3923/jm.2007.266.271.
[63] Ogunwande I, Olawore N, Ekundayo O, Walker TM, Schmidt JM, Setzer WN. Studies on the essential oils composition, antibacterial and cytotoxicity of Eugenia uniflora L. Int J Aromather, 15(3):147-52, 2005. doi: 10.1016/j.ijat.2005.07.004.
[64] Gülçina İ, Şatb İG, Beydemira Ş, Elmastaşc M, Küfrevioglu Öİ. Comparison of antioxidant activity of clove (Eugenia caryophylata Thunb) buds and lavender (Lavandula stoechas L.). Food Chem, 8(3):393-400, 2004.

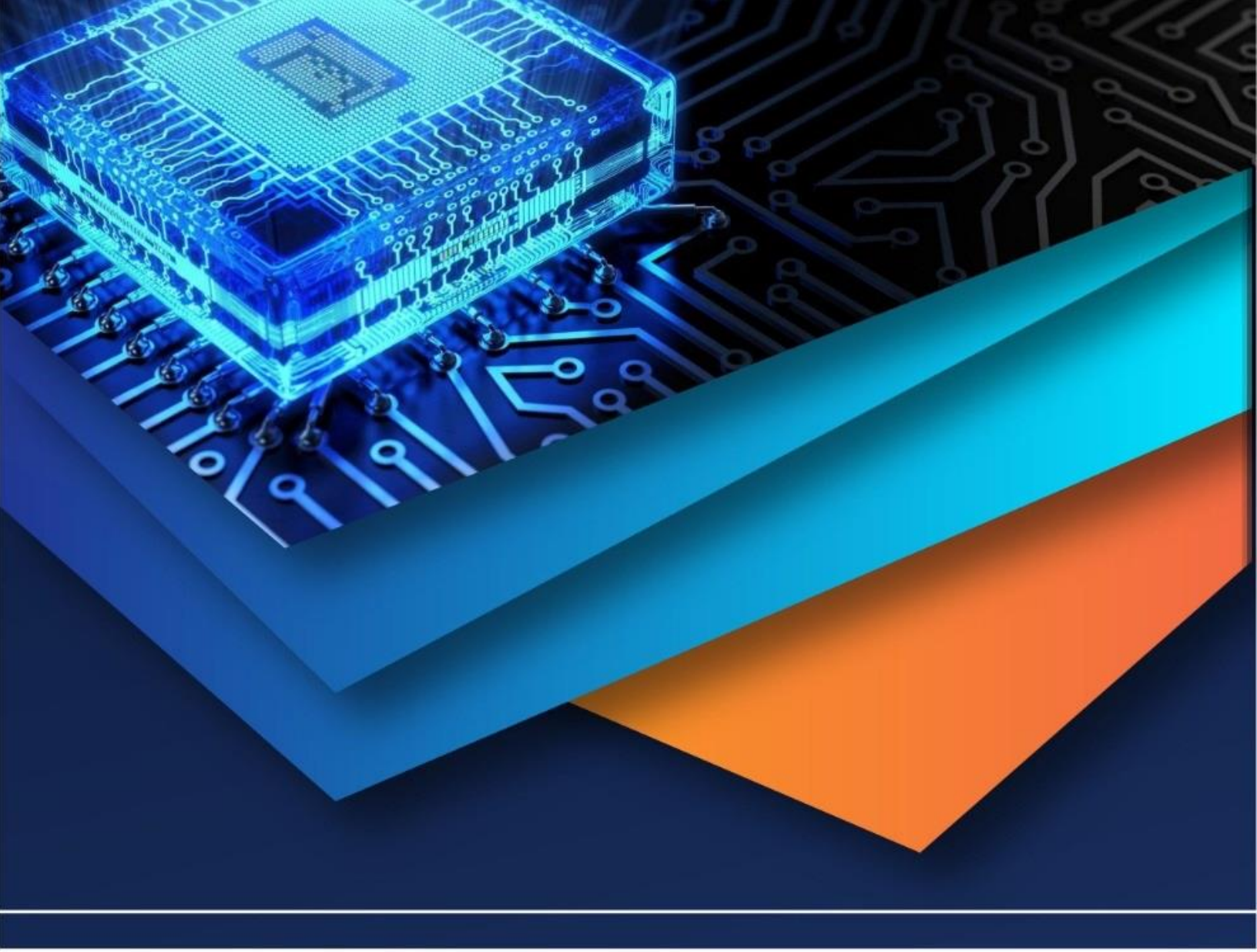
[65] Silva F, Ferreira S, Queiroz JA, Domingues FC. Coriander (Coriandrum sativum L.) essential oil: its antibacterial activity and mode of action evaluated by flow cytometry. J Med Microbiol, 60(10):1479-86, 2011. doi: 10.1099/jmm.0.034157-0, PMID 21862758.
[66] Dissanayake KCG, Fernando WSK, Perera WPRT. Investigation of the phytochemistry of Coriandrum sativum To combat against viral infections. Int J Innov Pharm Sci Res, 8(06):1-10, 2020.
[67] Pathak NL, Kasture SB, Bhatt NM, Rathod JD. Phytopharmacological properties of coriander Sativumas a potential medicinal tree: an overview. J Appl Pharm Sci, 4:20-5, 2011.
[68] Rajeshwari CU, Andallu B. Oxidative stress in NIDDM patients: influence of coriander (Coriandrum sativum) seeds. Res J Pharm Biol Chem Sci, 1:3, 2011.
[69] Silva F, Ferreira S, Queiroz JA, Domingues FC. Coriander (Coriandrum sativum L.) essential oil: its antibacterial activity and Mode of Action Evaluated by Flow cytometry. J Med Microbiol, 60(10):1479-86, 2011b. doi: 10.1099/jmm.0.034157-0, PMID 21862758.
[70] Rathabai V, Kanimozhi D. Evaluation of antimicrobial activity of Coriandrum sativum. Int J Sci Res Rev, 3:01-10, 2012.
[71] Wu TT, Tsai CW, Yao HT, Lii CK, Chen HW, Wu YL, et al. Suppressive effects of extracts from the aerial part of Coriandrum sativum L. on LPS-induced inflammatory responses in murine RAW 264.7 macrophages. J Sci Food Agric, 90(11):1846-54, 2010. doi: 10.1002/jsfa.4023, PMID 20549653.
[72] Park G, Kim HG, Lim S, Lee W, Sim Y, Oh MS. Coriander alleviates 2,4- dinitrochloro benzene-induced contact dermatitis-like skin lesions in mice. J Med Food, 17(8):862-8, 2014. doi: 10.1089/jmf.2013.2910, PMID 24963872.
[73] Nair V, Singh S, Gupta YK. Anti-granuloma activity of Coriandrum sativum in experimental models. J Ayurveda Integr Med, 4(1):13-8, 2013. doi: 10.4103/0975-9476.109544, PMID 23741156.
[74] Kumar CS, Bhattacharya S. Tamarind seed: properties, processing and utilization. Crit Rev Food Sci Nutr, 48(1):1-20, 2008. doi: 10.1080/10408390600948600, PMID 18274963.
[75] El-Siddig K, Gunasena HPM, Prasa BA, Pushpakumara DKNG, Ramana KVR, Vijayanand P, et al. Tamarind – Tamarindus indica L. Fruits for the future 1. Southampton, UK: Southampton Centre for Underutilized Crops, 188 p, 2006.
[76] Tsuda T, Watanabe M, Ohshima K, Yamamoto A, Kawakishi S, Osawa T. Antioxidative components isolated from the seed of tamarind (Tamarindus indica L.). J Agric Food Chem, 42(12):2671-4, 1994. doi: 10.1021/jf00048a004.
[77] Kengaiah J, Nandish SKM, Ramachandraiah C, Chandramma, Shivaiah A, Vishalakshi GJ, et al. Protective effect of tamarind seed coat ethanol extract on eryptosis induced by oxidative stress. Biochemistry (Mosc), 85(1):119-29, 2020. doi: 10.1134/S0006297920010113, PMID 32079523.
[78] Martinello F, Soares SM, Franco JJ, Santos AC, Sugohara A, Garcia SB, et al. Hypolipemic and antioxidant activities from Tamarindus indica L. pulp fruit extract in hypercholesterolemic hamsters. Food Chem Toxicol, 44(6):810-8, 2006. doi: 10.1016/j.fct.2005.10.011, PMID 16330140.
[79] Doughari JH. Antimicrobial activity of Tamarindus indica Linn. Trop J Pharm Res, 5(2):597-603, 2006. doi: 10.4314/tjpr.v5i2.14637.
[80] Al-Fatimi M, Wurster M, Schröder G, Lindequist U. Antioxidant, antimicrobial and cytotoxic activities of selected medicinal plants from Yemen. J Ethnopharmacol, 111(3):657-66, 2007. doi: 10.1016/j.jep.2007.01.018, PMID 17306942.
[81] El-Siddig K, Ebert G, Lüdders P. Tamarind (Tamarindus indica L.): a review on a multipurpose tree with promising future in the Sudan. J Appl Bot Angew Bot, 73:202-5, 1999.
[82] De Caluwé E, Halamouá K, Van Damme P. Tamarindus indica L. – a review of traditional uses, phytochemistry and pharmacology. Afr Focus, ;23(1):53-83, 2010. doi: 10.1163/2031356X-02301006.
[83] Gabari M, Dabo NT, Hassan A, Dahiru M. Yusha'u. Biological activity and phytochemical constituents of Tamarindus indica stem bark extracts. Sky J Microbiol Res, 2:67-71, 2014.
[84] Ameeramja J, Perumal E. Possible modulatory effect of tamarind seed coat extract on fluoride-induced pulmonary inflammation and fibrosis in rats. Inflammation, 41(3):886-95, 2018. doi: 10.1007/s10753-018-0743-5, PMID 29508183.
[85] Sundaram MS, Hemshekhar M, Santhosh MS, Paul M, Sunitha K, Thushara RM, et al. Tamarind seed (Tamarindus indica) extract ameliorates adjuvant-induced arthritis via regulating the mediators of cartilage/bone degeneration, inflammation and oxidative stress [sci rep:11117]. Sci Rep, 5:11117, 2015. doi: 10.1038/srep11117, PMID 26059174.
[86] Periasamy S, Lin CH, Nagarajan B, Sankaranarayanan NV, Desai UR, Liu MY. Mucoadhesive role of tamarind xyloglucan on inflammation attenuates ulcerative colitis. J Funct Foods, 47:1-10, 2018. doi: 10.1016/j.jff.2018.05.035, PMID 30555535.
[87] Srinivasan K. Cumin (Cuminum cyminum) and black cumin (Nigella sativa) seeds: traditional uses, chemical constituents, and nutraceutical effects. Food Qual Saf, 2(1):1-16, 2018. doi: 10.1093/fqsafe/fyx031.
[88] Amin B, Hosseinzadeh HH. Black Cumin (Nigella sativa) and its active constituent, thymoquinone: an overview on the analgesic and anti-inflammatory effects. Planta Med, 82(1-2):8-16, 2016. doi: 10.1055/s-0035-1557838, PMID 26366755.
[89] Salem ML. Immunomodulatory and therapeutic properties of the Nigella sativa L. seed. Int Immunopharmacol, 5(13-14):1749-70, 2005. doi: 10.1016/j.intimp.2005.06.008, PMID 16275613.
[90] Worthen DR, Ghosheh OA, Crooks PA. The in vitro anti-tumor activity of some crude and purified components of black seed, Nigella sativa L. Anticancer Res, 18(3A):1527-32, 1998. PMID 9673365.
[91] Hosseinzadeh H, Parvardeh S, Asl MN, Sadeghnia HR, Ziaee T. Effect of thymoquinone and Nigella sativa seeds oil on lipid peroxidation level during global cerebral ischemia-reperfusion injury in rat hippocampus. Phytomedicine, 14(9):621-7, 2007. doi: 10.1016/j.phymed.2006.12.005, PMID 17291733.
[92] Shetty RS, Singhal RS, Kulkarni PR. Antimicrobial properties of cumin. World J Microbiol Biotechnol, 10(2):232-3, 1994. doi: 10.1007/BF00360896, PMID 24420956.
[93] Motamedifar M, Ghafari N, Shirazi PT. The effect of cumin seed extracts against herpes simplex virus Type 1 in Vero cell culture. Iran J Med Sci, 35(4), 2010.
[94] Boulos L. Medicinal plants of North Africa. 1st ed Reference Pubns: Algonac: MI; 1983. ISBN: 10. p. 286. PMID 0917256166.
[95] Agarwal R, Kharya MD, Shrivastava R. Antimicrobial and anthelminthic activities of the essential oil of Nigella sativa Linn. Indian J Exp Biol, 1979;17(11):1264-5, 1979. PMID 549848.
[96] Akhtar MS, Riffat S. Field trial of Saussurea lappa roots against nematodes and Nigella sativa seeds against cestodes in children. J Pak Med Assoc, 41(8):185-7, 1991. PMID 1942479.
[97] Mahmoud MR, El-Abhar HS, Saleh S. The effect of Nigella sativa oil against the liver damage induced by Schistosoma mansoni infection in mice. J Ethnopharmacol, 79(1):1-11, 2002. doi: 10.1016/s0378-8741(01)00310-5, PMID 11744288.

[98] Aboul Ela MA, El-Shaer NS, Ghanem NB. Antimicrobial evaluation and chromatographic analysis of some essential and fixed oils. Pharmazie, 51(12):993-4, 1996. PMID 8985990.
[99] Hanafy MS, Hatem ME. Studies on the antimicrobial activity of Nigella sativa seed (black cumin). J Ethnopharmacol, 34(2-3):275-8, 1991. doi: 10.1016/0378-8741(91)90047-h, PMID 1795532.
[100] Aboul-Ela EI. Cytogenetic studies on Nigella sativa seeds extract and thymoquinone on mouse cells infected with schistosomiasis using karyotyping. Mutat Res, 516(1-2):11-7, 2002. doi: 10.1016/s1383-5718(01)00333-3, PMID 11943605.
[101] Salem ML, Hossain MS. Protective effect of black seed oil from Nigella sativa against murine cytomegalovirus infection. Int J Immunopharmacol, 22(9):729-40, 2000. doi: 10.1016/s0192-0561(00)00036-9, PMID 10884593.
[102] Morshedi D, Aliakbari F, Tayaranian-Marvian A, Fassihi A, Pan-Montojo F, Pérez-Sánchez H. Cuminaldehyde as the major component of Cuminum cyminum, a natural aldehyde with inhibitory effect on alpha synuclein fibrillation and cytotoxicity. J Food Sci, 80(10):H2336-45, 2015. doi: 10.1111/1750-3841.13016, PMID 26351865.
[103] Kalaivani P, Saranya RB, Ramakrishnan G, Ranju V, Sathiya S, Gayathri V, et al. Cuminum cyminum, a dietary spice, attenuates hypertension via endothelial nitric oxide synthase and NO pathway in renovascular hypertensive rats. Clin Exp Hypertens, 35(7):534-42, 2013. doi: 10.3109/10641963.2013.764887, PMID 23402543.
[104] Vador N, Jagtap AG, Damle A. Vulnerability of Gastric Mucosa in Diabetic Rats, Its pathogenesis and Amelioration by Cuminum cyminum. Indian J Pharm Sci, 74(5):387-96, 2012. doi: 10.4103/0250-474X.108413, PMID 23716866.
[105] Mokhtari-Zaer A, Norouzi F, Askari VR, Khazdair MR, Roshan NM, Boskabady M, et al. The protective effect of Nigella sativa extract on lung inflammation and oxidative stress induced by lipopolysaccharide in rats. J Ethnopharmacol, 253:112653, 2020. doi: 10.1016/j.jep.2020.112653.
[106] Abbasnezhad A, Niazmand S, Mahmoudabady M, Rezaee SA, Soukhtanloo M, Mosallanejad R, et al. Nigella sativa L. seed regulated eNOS, VCAM-1 and LOX-1 genes expression and improved vasoreactivity in aorta of diabetic rat. J Ethnopharmacol, 228:142-7, 2019. doi: 10.1016/j.jep.2018.09.021, PMID 30223051.
[107] Beheshti F, Norouzi F, Abareshi A, Khazaei M, Alikhani V, Moussavi S, et al. Nigella sativa prevented liver and renal tissue damage in lipopolysaccharide-treated rats. Saudi J Kidney Dis Transpl, 29(3):554-66, 2018. doi: 10.4103/1319-2442.235184, PMID 29970731.
[108] Bordoni L, Fedeli D, Fiorini D, Gabbianelli R. Extra virgin olive oil and Nigella sativa oil produced in central Italy: A comparison of the nutrigenomic effects of two Mediterranean oils in a low-grade inflammation model. Antioxidants (Basel), 9(1):20, 2019. doi: 10.3390/antiox9010020, PMID 31878334.
[109] Khaldi T, Chekchaki N, Boumendjel M, Taibi F, Abdellaoui M, Messarah M, et al. Ameliorating effects of Nigella sativa oil on aggravation of inflammation, oxidative stress and cytotoxicity induced by smokeless tobacco extract in an allergic asthma model in Wistar rats. Allergol Immunopathol (Madr), 46(5):472-81, 2018. doi: 10.1016/j.aller.2018.02.005, PMID 29739684.
[110] Abulfadl YS, El-Maraghy NN, Ahmed AE, Nofal S, Abdel-Mottaleb Y, Badary OA. Thymoquinone alleviates the experimentally induced Alzheimer's disease inflammation by modulation of TLRs signaling. Hum Exp Toxicol, 37(10):1092-104, 2018. doi: 10.1177/0960327118755256, PMID 29405769.
[111] Visweswara Rao P, Gan SH. Cinnamon: A multifaceted medicinal plant. Evid Based Complement Alternat Med, 12, 2014.
[112] Friedman M, Henika PR, Mandrell RE. Bactericidal activities of plant essential oils and some of their isolated constituents against Campylobacter jejuni, Escherichia coli, Listeria monocytogenes, and Salmonella enterica. J Food Prot, 65(10):1545-60, 2002. doi: 10.4315/0362-028x-65.10.1545, PMID 12380738.
[113] Inouye S, Takizawa T, Yamaguchi H. Antibacterial activity of essential oils and their major constituents against respiratory tract pathogens by gaseous contact. J Antimicrob Chemother, 47(5):565-73, 2001. doi: 10.1093/jac/47.5.565, PMID 11328766.
[114] López P, Sánchez C, Batlle R, Neŕın C. Solid- and vaporphase antimicrobial activities of six essential oils: susceptibility of selected foodborne bacterial and fungal strains. J Agric Food Chem, 53(17):6939-46, 2005. doi: 10.1021/jf050709v, PMID 16104824.
[115] Smith-Palmer A, Stewart J, Fyfe L. Antimicrobial properties of plant essential oils and essences against five important food-borne pathogens [lett]. Lett Appl Microbiol, 26(2):118-22, 1998. doi: 10.1046/j.1472-765x.1998.00303.x, PMID 9569693.
[116] Gruenwald J, Freder J, Armbruester N. Armbruester N. Janine Freder and Nicole Armbruester; cinnamon health. Crit Rev Food Sci Nutr, 50(9):822-34, 2010. doi: 10.1080/10408390902773052, PMID 20924865.
[117] Xia T, Gao R, Zhou G, Liu J, Li J, Shen J. Trans-cinnamaldehyde inhibits IL-1β- stimulated inflammation in chondrocytes by suppressing NF-κB and p38-JNK pathways and exerts chondrocyte protective effects in a rat model of osteoarthritis. BioMed Res Int, 4039472, 2019. doi: 10.1155/2019/4039472.
[118] Lee HS, Kim BS, Kim MK. Suppression effect of Cinnamomum cassia bark-derived component on nitric oxide synthase. J Agric Food Chem, 50(26):7700-3, 2002. doi: 10.1021/jf020751f, PMID 12475291.
[119] Fu Y, Yang P, Zhao Y, Zhang L, Zhang Z, Dong X, et al. trans- cinnamaldehyde Inhibits Microglial Activation and Improves Neuronal Survival against neuroinflammation in BV2 Microglial Cells with lipopolysaccharide Stimulation. Evid Based Complement Alternat Med, 4730878, 2017. doi: 10.1155/2017/4730878.
[120] Han X, Parker TL. Anti-inflammatory activity of cinnamon (Cinnamomum zeylanicum) Bark Essential Oil in a Human Skin Disease Model [Cinnamomum zeylanicum]. Phytother Res, 31(7):1034-8, 2017. doi: 10.1002/ptr.5822, PMID 28444928.
[121] Hong JW, Yang GE, Kim YB, Eom SH, Lew JH, Kang H. Anti-inflammatory activity of cinnamon water extract in vivo and in vitro LPS-induced models. BMC Complement Altern Med, 12:237, 2012. doi: 10.1186/1472-6882-12-237, PMID 23190501.
[122] Lee BJ, Kim YJ, Cho DH, Sohn NW, Kang H. Immunomodulatory effect of water extract of cinnamon on anti-CD3-induced cytokine responses and p38, JNK, ERK1/2, and STAT4 activation. Immunopharmacol Immunotoxicol, 33(4):714-22, 2011. doi: 10.3109/08923973.2011.564185, PMID 22053946.
[123] Koh WS, Yoon SY, Kwon BM, Jeong TC, Nam KS, Han MY. Cinnamaldehyde inhibits lymphocyte proliferation and modulates T-cell differentiation. Int J Immunopharmacol, 20(11):643-60, 1998. doi: 10.1016/s0192-0561(98)00064-2, PMID 9848396.
[124] Kareparamban JA, Nikam PH, Jadhav AP, Kadam VJ. Ferula asafoetida "Hing": a review. Res J Pharm Biol Chem Sci, 3(2):775-86, 2012.
[125] Capasso R, Izzo AA, Borrelli F, Russo A, Sautebin L, Pinto A, et al. Effect of piperine, the active ingredient of black pepper, on intestinal secretion in mice. Life Sci. 71(19);71:2311-7, 2002. doi: 10.1016/s0024-3205(02)02019-2, PMID 12215378.
[126] Alqasoumi S. Anxiolytic effect of Ferula assafoetida L. in rodents. in rodents. J Pharmacogn Phytother, 4(6):86-90, 2012. doi: 10.5897/JPP12.027.
[127] Ghannadi A, Fattahian K, Shokoohinia Y, Behbahani M, Shahnoush A. Antiviral Evaluation of Sesquiterpene Coumarins from Ferula assafoetida against HSV-1. Iran J Pharm Res, 13(2):523-30, 2014. PMID 25237347.

[128] Verma S, Khambhala P, Joshi S, Kothari V, Patel T, Seshadri S. Evaluating the role of dithiolane rich fraction of Ferula asafoetida (Apiaceae) for its antiproliferative and apoptotic properties: in vitro studies. Exp Oncol, 41(2):90-4, 2019. doi: 10.32471/exp-oncology.2312-8852.vol-41-no-2.12989, PMID 31262162.

[129] Bagheri SM, Abdian-Asl A, Moghadam MT, Yadegari M, Mirjalili A, Zare-Mohazabieh F, et al. Antitumor effect of Ferula assafoetida oleo gum resin against breast cancer induced by 4T1 cells in BALB/c mice. J Ayurveda Integr Med, 8(3):152-8, 2017. doi: 10.1016/j.jaim.2017.02.013, PMID 28690055.

[130] Mallikarjuna GU, Dhanalakshmi S, Raisuddin S, Rao AR. Chemomodulatory influence of Ferula asafoetida on mammary epithelial differentiation, hepatic drug metabolizing enzymes, antioxidant profiles and N-methyl-N-nitrosourea-induced mammary carcinogenesis in rats. Breast Cancer Res Treat, 81(1):1-10, 2003. doi: 10.1023/a:1025448620558, PMID 14531492.



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