

SYZYGIUM AROMATICUM (CLOVE): A REVIEW ON VARIOUS PHYTOCHEMICALS AND PHARMACOLOGICAL ACTIVITIES IN MEDICINAL PLANT

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Article Received on
28 July 2020,

Revised on 18 August 2020,
Accepted on 08 Sept. 2020,

DOI: 10.20959/wjpr202011-18663

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ABSTRACT

Syzygium aromaticum is general name is clove. That is belonging to family myrtaceae. Clove is famous the Indian flavor used as spice and medicinal properties are contained. They are mainly ayurvedic medicine used in ayurveda. It a dark brown colour, taste pungent, odour is slightly aromatic. Clove-bud is extract obtained from the essential oil. Essential oil are also called as volatile-oil (aromatic oil). Eugenol is a main chemical constituent of the clove. It used in as expectorant, teeth care, as anesthesia. They solvent system n-Hexane, petroleum ether, chloroform, ethanol, methanol, water are used in separation of eugenol from clove. Clove has containing more phytochemical constituents such as eugenol, acetyl eugenol, Alpha and Beta-caryophyllene, vanillin, tannins etc. that the clove has shows

some pharmacological activities such as anti-oxidant, anti-cancer, anti -microbial, anti-inflammatory, anti-pyretic, anti-viral, anti-diabetic, anesthetic, analgesic, anti-carcinogenic, antibacterial, antifungal, antibiotic. The review represents an overview phytochemical and pharmacologically activity on the *syzygium aromaticum*.

KEYWORDS: Introduction of clove, phylotoxy of plant, pharmacognosy, phytochemicals, pharmacological activity of *syzygium aromaticum*.

1. INTRODUCTION

The clove is usually known as "lavang." Due to the increase in nutrition and medicinal properties, Plants' importance in human life has increased every day. The term clove is derived from 'clove' and 'clou' meaning 'nail.' This is used mainly in Ayurvedics.^[1] Clove is the topical evergreen Myrtaceae family tree native to the islands of Maluku in east Indonesia. The color is small brown, floral buds, and a spice is used. It was used as food preservatives, flavoring agents and nutritional additives, medicinal coloring agents.^[2] Health, cosmetic, nutritional and agricultural use clove. It is commonly used for tooth care.^[3] This is commonly used as an expectorant for the treatment of dental discomfort, the digestive problem, oral ulceration, mosquito repellent.^[4] Clove is a pharmacologically active medicinal plant that includes Anti-oxidant, anti-pyretic, anti-viral, anti-microbial, anti-diabetic, anti-inflammatory, analgesic, anti-platelet, anti-stress, anti-disease, anti-carcinogenic in cervical cancer. The clove is available in three types of essential oil.^[5] Clove is amongst the most essential sources of Phenolic compounds, including eugenol (80% -90%), eugenyl acetate (15% -17%), and beta-caryophyllene (5% -12%), alpha-humulene (0.55%), alpha-terpenyl acetate (0.1%), and methyl eugenol (0.2%).^[6] The clove oil extracted from the dried floral buds of the clove provide as a topical treating pain and as a healing factor. The flowers, stalks and clove tree leaves are obtained from the distillation of clove oil.^[7] Eugenol is the clove's principal bioactive ingredient. For oral diseases, it is used as an antiseptic.^[8]



Fig. (A): Clove dried flower buds, (B) Clove plant, (C) Cloves flowering, (D) Fruits and seeds.

2. Phylotoxy^[9]

Rich loamy soil with a high humus quality is perfect for clove cultivation. In open sandy loam and laterite soil of southern kerala area and soil with good moisture, good drainage, it is also found to grow favorably. The pH of soil should vary from 4.0-5.6. Soil water mining should be prevented. This needs of higher moisture content, but also develops well close to the sea. Rainy season it within ranges of 150-250 cm another cultivation and place factor that ranges from ocean level to 900 m. After 7-8 years, the plant starts to grow, and satisfactory yield per hectare of drugs is achieved only after 15-20 years of development. The clove is strongly tropical and demands a dry, moist and wet. Humid climate and well distributed annually with an ideal requirement to cultivate the crop normally and commercially.

Table 1: Taxonomy.

| | |
|----------------|-------------------|
| Kingdom | Plantae |
| Sub Kingdom | Tracheobionta |
| Super Division | Spermatophyta |
| Division | Magnoliphyta |
| Class | Magnoliopsida |
| Subclass | Rosidae |
| Order | Myrtales |
| Family | Myrtaceae |
| Genus | <i>Syzygium</i> |
| Species | <i>aromaticum</i> |

Table 2: Vernacular name of syzygium arometicum.

| | |
|-----------|---|
| Sanskrit | Devkusuma, Devapuspa, Lavanga, Sriprasum, Chandanpushpaks |
| English | Clove, Clovos, Caryophyllus, Carophyllus |
| Botanical | Eugenia Caryophyllus, Syzygium Aromaticum |
| Hindi | Lavang, Laung |
| Marathi | Lavang |
| Malayalam | Grampus, Karayampu |
| Kannada | Krambu, Daevakusuma, Lavanga |
| Tamil | Kirampu, Kiraambu, Grambu |
| Bengali | Lavanga |
| Gujrati | Lavang |
| Oriya | Labanga |
| Urdu | Laung |

3. MORPHOLOGY OF CLOVE^[10,11]

Hpanthium is the upper crow or cap of clove. The lower portion is 10-13 mm in length and 4 mm and 2 mm in thickness. Four spreading thick, squatted, cylindrical stem, sharp sepals are about 3mm. Approximately 5-5,5 mm long and dome shaped corolla. Four petals in bowl

shape. Color is a dark brown, odour is slightly aromatic, its taste is pungent. The top section is created of calyx, corolla, stamen and style, and shows bilocular ovaries and oil glands. Corolla is a dome shaped in yellow with imbricated membranous petals. It is a conical myrtle tree, medium in size, with a straight trunk that grows in height from 10 to 12 m. Branches semi straight, and it occurs greyish. Leaves are tall, elliptical and obovate, glabrous and have many oil glands on the lower surface. The plant begins flowering in about seven years and blooms for more than 80 years.

The clove tree consists of leaves and buds (the commercial component of the crop) and flowering bud starts four years after planting. It is one of the most important drugs in Indian indigenous medicine, especially Unani. The clove is an herb. The clove is a tree. People make medicine using their oils and drying flowers, leaves and stems.

4. MICROSCOPY^[12,13,14]

The transverse segment should be taken through the short upper portion of the bilocular ovary, the hypanthium, and the hypanthium area as well. This has a single epidermis layer lined with thick cuticle. It is a single sheet, straight walled cells with anomocytic (ranunculaceous) stomata, very thick cuticle. The cortex has the peripheral area of three distinct regions with two to three cells of schizolysigenous oil glands, rooted in a parenchymatous cell. The middle zone consists of three to five lignified spiral vessels with a bicollateral vascular ring. There may be isolated pericyclic fibers (lignified) around the vascular ring. By 5-6 lignified vessels Xylem. Parenchyma containing lacuna or air gaps (aerenchyma). Central columella contains dense parenchymatous walled cells containing calcium oxalate cluster crystals and 20-25 small vascular bundles. The ovary with ovarian wall, parenchymatous mesophyll, ovules with axile placentation, Starch and stone cells are absent in a transverse section via region of ovary.

4.1 POWDER MICROSCOPY^[15]

Microscopic inspection reveals the different sections-

Oil Glands- Aerenchyma that reveals long oval schizolysigenous oil glands.

Aerenchyma- A part of loose air-space parenchyma

Pollen grains- Diameter 15-20 μ small in shape, bioconvex, rounded or triangular

Fibres- Sclerenchymatous fibers of cells Parenchymatous

Anther- Fibrous anther stratum with reticulated cells Contains spherulites

Calcium oxalate- Contains spherulites

5. COLLECTION^[16]

There is bud formation after 7-8 years of age. Developing clove buds is gathered until they are fully grown.

5.1. Time of Collection^[17]

When the buds of the clove appear light brown in colour. A tree produces a clove of 2.5-4.5 kg at a time. Such immature buds in the clove then dried in the sunlight and the used for 4-5 days. Kokate. C. K. Purohit.

6. CHEMICAL CONSTITUENTS^[18,9,20]

Clove is made of both volatile and non-volatile constituents.

6.1. Essential Oils

Clove contains different volatile oil from, Blades, Stalk, Knuckles, and Fruit. These oils are significantly different in consistency and yield. The yields and compositions of the oils obtained are determined by the quality of its origin, nature, varieties and manufactured goods, maturity of harvest, pre-post distillation and distillation method. The main constituent of all oil groups is eugenol.

6.2. Buds

High varieties cloves are contain 15 percent to 20 percent volatile oil. Eugenol eugenyl acetate and β -caryophyllene dominate the material, which is collectively made up 99 percent of the oil. Additionally, Methylamyl-ketone, methyl-salicylate, alpha-and beta-humulene, benzal-dehyde, beta-ylangen, and chavicol are components of the oil and are smaller amount oil present in clove is methylamylketone, methylsalicylate. They are responsible for the distinctive, amusing clove fragrance. As in Madagascar, Eugenol, eugenyl-acetate, and beta-caryophyllene have occupied are clove bud and stems oils. The stem contains high levels of eugenol. The content of eugenyl-acetate in the bud oil was advanced. Clove bud oil had eugenol at 73.5–79.7 percent and eugenyl acetate, while stems oil had eugenol at 76.4 percent to 84.8 percent, eugenyl-acetate at 1.5–8.0 percent. The two contains (7.3% to 12.4%) beta-caryophyllene and (1.0–1.4%) alpha-humulene, 36 compounds from the clove buds' volatile oil were identified. India's clove buds (12.9–18.5%) oil, (44–55%) eugenol.

6.3. Leave

The leaves essential oil yield 3.0–4.8%. Throughout the various Stages of growing the leaves, essential oil substance showed that excessive eugenol content in leaves s at maturity between 38.3 percent and 95.2 percent, while eugenyl-acetate content (51.2% -1.5%) and caryophyllene content (6.3% -0.2%) reduced at maturity. Clove-buds, leaf oil if contain a variety of material, including all types of terpenes, aldehydes, and ketones.

6.4. Stem

Stem contains 6% of yields volatile oil and 80.2% of eugenol, 6.6% of β -caryophyllene and other minor components.

6.5. Fruits

The fruits are contains 50% and 5%5 eugenol.

6.6. Non Volatil Constitutions^[20]

Clove, consisting of tannins, sterols, tri-terpenes and flavonoids, has isolated hardly any non-volatiles.

6.7. Tannin

10% – 13% of tannins present in clove buds. Have the similer chemical conformation even as the gallotannic-acid. It separated Eugenin, and ellagi-tannin there the cloves. lavang leaves were separated from 2, 4, 6-trihydroxy-acetophenone-3-glucopyranoside, Eugenol-glucoside gallate, a chromone C-glycoside, galloyl, and hexa-hydroxy di-phenyl esters. Furthermore, two ellagitannins, syzyginine A (1,2,3 -tri-O-galloyl-4, 6-(S)-tergalloyl-beta-D-glucoside) and syzyginine B, were separated there the clove-leaves too.

6.8. Triterpene

Clove buds contain around two per cent oleanolic acid, triterpene. Isolated maslinic acid from clove buds by Narayanan and Natu (1974). Only 2 α -hydroxyoleanolic acid was isolated from clove.

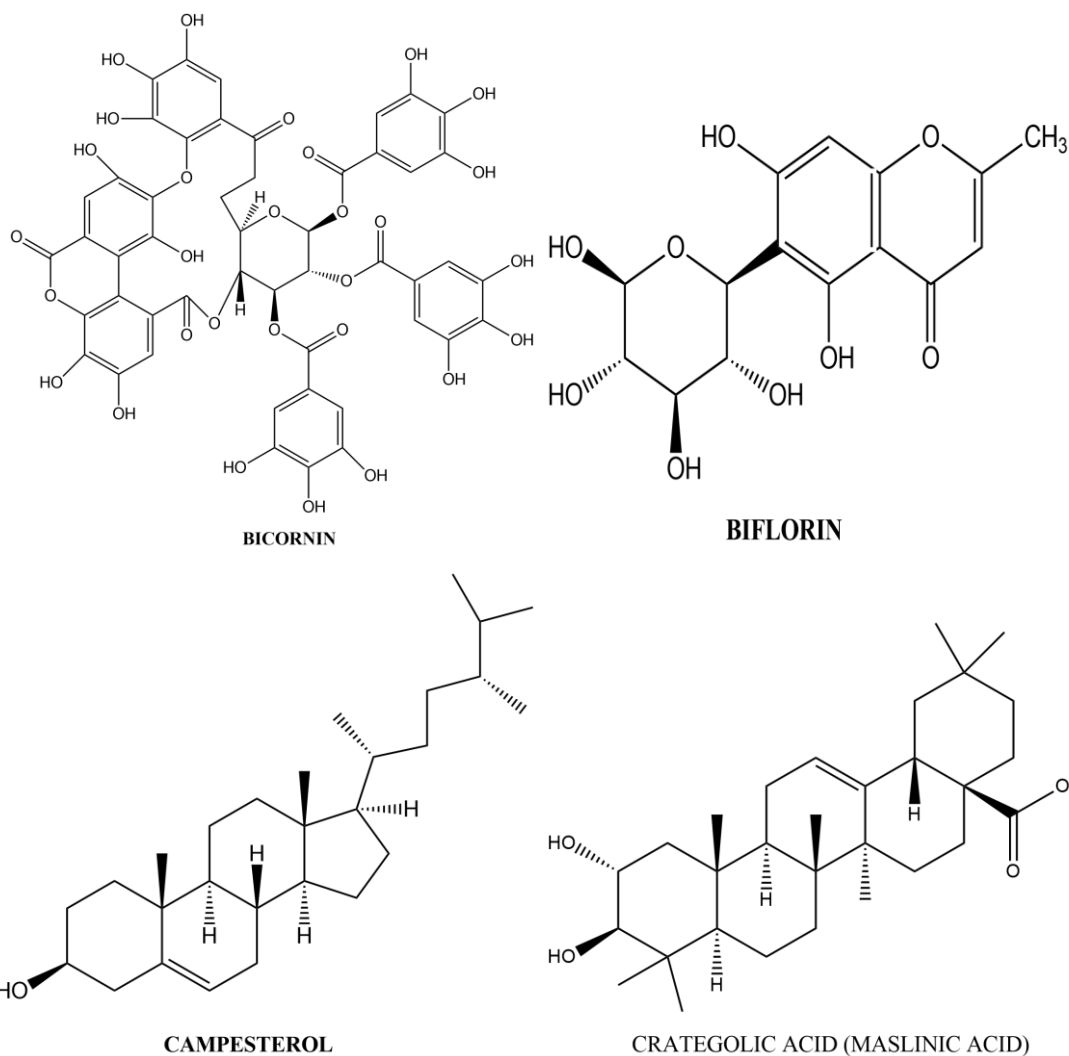
6.9. Sterols

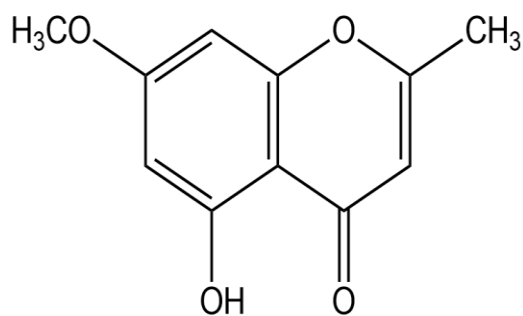
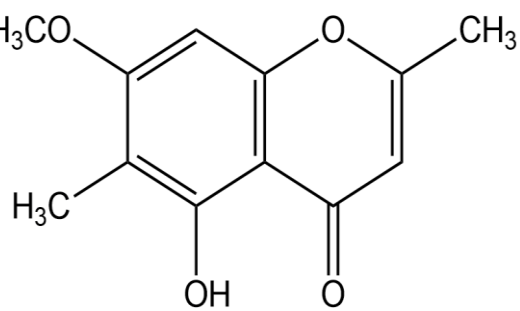
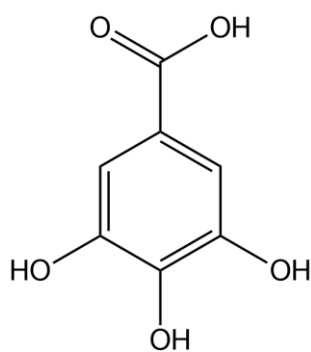
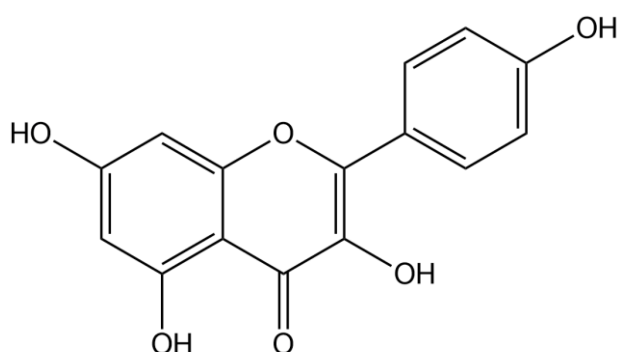
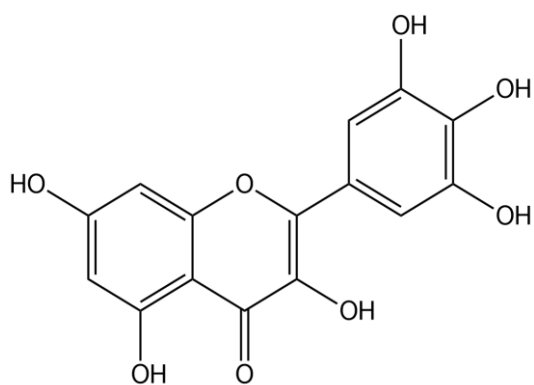
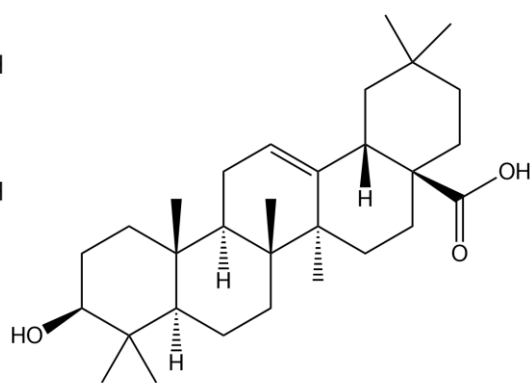
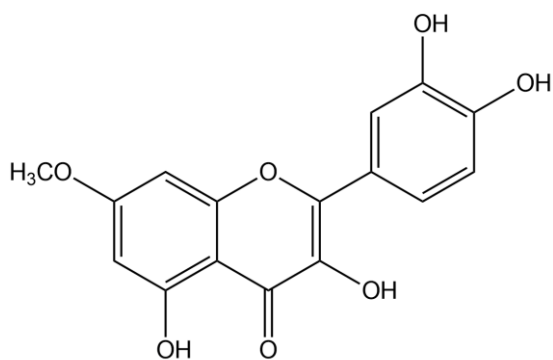
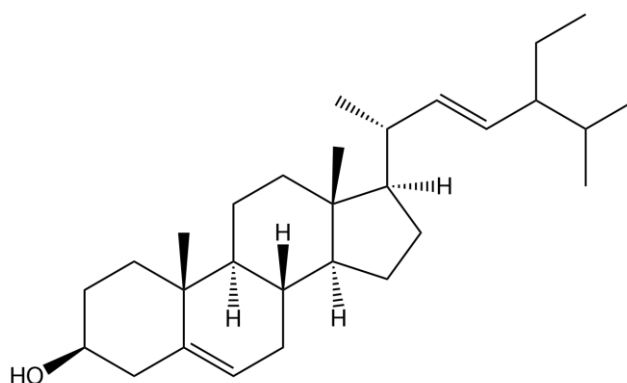
Clove-isolated sterols are involves sito-sterol, stigma-sterol, and campesterol.

6.10. Flavonoid

A C-glucoside chromone, iso-biflorin (5, 7-dihydroxy-2-methoxy-chromone-8-C- β -D-glucopyranoside), and biflorin are extracted there the extracts of clove ethanol. If the seed ethanolic extracts separated from Apigenin 6-C-[β -D-xylopyranosyl-(12'')- β -D-galactopyranoside]-7-O- β -D-glucopyranoside and Apigenin-6-C-[β -D-xylopyranosyl-(12'')- β -D-galactopyranoside]-7-O- β -D-(6-O-p-coumarylgluco-pyranoside).

7. Structure of Some Compounds Present In *Syzygium Aromaticum*^[20]



**EUGENIN****EUGENITIN****GALLIC ACID****KAEMFEROL****MYRICETIN****OLEANOLIC ACID****RHAMNETIN****STIGMASTEROL**

8. PHARMACOLOGICAL LITERATURE REVIEW

8.1. Antimicrobial Activity: Eugenol exhibits antimicrobial activity toward fungi, as well as a widely range of gram-positive and gram-negative bacteria. Eugenol is naturally occurring essential oil i.e., hydroxyphenyl propene belonging to family myrtaceae responsible for human infection diseases, Oral cavity eugenol disease, food-borne pathogens eugenol demonstrates bioactive compounds with broad range anti-microbial activity against both plank-tonic and sessile cells carrying foodborne micro-organisms and human diseases (Marchese A. *et al*, 2017).

8.2. Anti-Oxidant Activity: Antioxidant activity above essential oil separated significant eugenol compounds and its derivative are determined using two the free radical scavenging assays in vitro-model involving 2,2 – di-phenyl-1-picryl hydrazyl (DDPH) and nitric oxides. The percentage inhibition was measured and reports were represented using ascorbic acid as normal in a term of IC_{50} value – uses (Concentration when compared at which free radicals is inhibition by 50 per cent) (Kaur K. *et al*, 2019).

This activity is evaluated with DPPH. Radical scavenging activity is the very common method to determine the activity. Capturing of free radical by eugenol is expressed as IC_{50} . Expresses the concentration needed to capture radicals as a medium of 50 per cent. As a result it shows strongly decreases anti-oxidant activity (Da Silva FFM. *et al*, 2018).

8.3. Antidiabetic Activity: There work is hypothesized to evaluate the anti-hyperglycemic ability are eugenol via defining activity are enzymes the involved in streptozotocin (STZ)-induced glucose metabolized in a diabetics rats. Increases in the activity of major carbohydrate metabolized enzymes such as hexo-kinase, pyruvate-kinase, glucose-6-phosphate-dehydrogenase, glucose-6-phosphatase, fructose-1, 6-bis-phosphatase, and liver biomarkers (AST, ALT, and ALP), creatine-kinase, and blood urea nitrogen's in serum, and diabetes rat blood have appreciably returned to nearly normal rates via eugenol administration. Eugenol dosing to improve body weight for diabetic rats and hepatic glycogen quality exemplify eugenol's anti-hyperglycemic ability in diabetic rats. Current findings indicate that eugenol in experimental diabetes may potentially boost activities of enzyme of glucose metabolized, and the prudent are extend from a scope the eugenol used in a trial of alleviate the adverse effect of diabetes (Srinivasan S. *et al*, 2013).

Lavang and insulin influence the activity of diabetes-related genes such as a phosphoenolpyruvate carboxy-kinase (PEPCK) glucose 6-phosphate (G6Pase) gene, investigating the antidiabetic effects of free and bound phenolic clove extracts against carbo-hydrate-hydrolyzing enzyme in a similar manner. Result the both extracts blocked dose-dependent alpha-amylase and alpha-glucosidase (Mbaveng A.T. *et al*, 2017).

8.4. Anticarcinogenic Activity: Clove essential oil these are demonstrate anticarcinogenic and antimutagenic ability due to good free radical scavenging activity. Many confirmatory studies have suggested chemo-preventive role of essential oils, showing in lung, skin and digestive cancers. Clove extract of ethyl acetate suppresses tumor growth and helps in the arrest and apoptosis of cell cycles. Eugenol behaves as a potential atom capable of obstructing multiple cell signaling pathways, especially the NF-kB. Eugenol are combine with gemcitabine on the cervical carcinoma and present that the combination of eugenol and gemcitabine, even in low concentration, would inhibit growth of cancer cells (Mittal M. *et al*, 2014).

8.5. Analgesic Activity: Popularly used in dental practices because of its potential to soothe tooth pain. The anesthesia effects on dental pain as well as analgesic and anti-inflammatory effect the animal model, suppressing prostaglandins and other inflammatory mediators to weaken the sensory receptors involved in pain perception, impair the capacity for action in sciatic nerves. (Mittal M. *et al*, 2014).

There human studies have shown that the clove plant has an analgesic effect on toothache. Present study to examine from possible analgesic outcome the essential-oil in mice was undertaken. The hot plate check was conducted as a reference record 15 min previous drug injection and then repeated after injection every 15 minutes. Measured test ANOVA found that in the animal's group treat with 5-10 and 20 percent essential-oil, the average percentage effect (MPE) was considerably higher than in the saline groups. Similarity are the between four treated a group show as that MPE in 10 % essential-oil groups are greater than the 2 percent and 5percent groups; there was the no significant differences between 10 percent and 20 percent group. The result of found studies show clove essential oil has analgesic effects in mice using hot plate tests (Husseini M. *et al*, 2011).

8.6. Anti-Inflammatory Activity: Essential oil open breathing channels, serving as an expectorant to treat many of the upper respiratory disorders including colds, eye sties, bronchitis, sinus disorders, S cough and asthma. In traditional clinical medicine, clove

was used to relieve nasal hindrance and musculoskeletal discomfort that indicates its anti-inflammatory function and the action is attributed to COX-2 inhibition. When inhaled, the aromatic oil could help to alleviate such breathing problems such as cough, colds, asthma, bronchitis, and sinusitis (Mittal M. *et al*, 2014).

8.7. Antiviral Activity: Plaque reduction assays investigated antiviral activity and the anti-viral mechanism of action was determined by administering the drugs to uninfected cells, infected viruses or herpesvirus-infected cells. Phenylpropanoids inhibited about 60–80% HSV infection and 40–98% sesquiterpenes that prevented herpes virus infection. Anise essential oil exhibited anti-HSV-1 activity on all isolated compounds by direct inactivation of free virus particles. Tested medications bind with particles of the herpesvirus, inactivating viral infectivity. The antiviral potential of the β -caryophyllene suggests that here in essential oils phenylpropanoids and sesquiterpenes contribute to their antiviral function as opposed to HSV (Astani A. *et al*, 2009).

8.8. Anticancer Activity: Showed cytotoxic effects of antimutagenic activity against cancer cell lines. Clove oil extracts demonstrated cytotoxic activity against cervical cancer Hela cells, MCF-7 cells and MDA-MB-231 cells for breast adeno-carcinoma, DU-145 cells for prostate-cancer, TE-13 cells for oesophageal-cancer. Cytotoxicity of methanol extract from clove buds was also reported against melanin formation, and it was found that aqueous clove infusion had a promising function in limiting the carcinogenesis process in 9, 10- dimethyl benz (a) anthracene-convinced skin carcinoma. There were also studies of anti-mutagenic activities of clove seeds extract (Mbaveng A.T. *et al*, 2017).

8.9. Anti Bactrial Activity: This research was conducted againsts gram-positives and gram-negatives bacteria, pathogenic fish bacteria isolated from Korea's cultivated olive flounder. CEO includes 7 chemical compounds including 83.63 percent eugenol disc - diffusion assay, micro, mbc test indicates that ceo eugenol inhibits growth gram positive and gram negative bacteria (Pathirana H.N.K.S. *et al*, 2019).

It shows synergic effect combined with rifampicin, isoniazid, ethambuton and pyrazinamide in m.tb includes multi drugs resistant with more precisely to bacillus than macrophages. Eugenol derivatives are more active against m.tb than eugenol. It possess are the less

activities of against gram-positives and gram-negatives bacteria (Almeida A.L.D. *et al*, 2019).

8.10. Antifungal Activity: Antifungal clove activity is increased if collected by isomerizing double bond or adding nitro group on the aromatic ring. Based on the relationship between fungicides, chemical structure and mechanism of action (MOA), activity for commercial fungicide BC-1000 is highly documented. As a result, the compound shows potential impact and can be used to design the natural compound's new and efficient balance (Olia A.F. *et al*, 2019).

8.11. Anesthetic Activity: in study, methyl-Isoeugenol show effects and was only active when higher dose is given. Isoeugenol as compound to methylisoeugenol shows similar activity and potency between eugenol and methyleugenol.eugenol is a allyl compound and is more active than propenyl isomer (iso eugenol) (Dallmeier K *et al*, 1981).

9. DISCUSSION AND CONCLUSION

The study, that are review in discuss pharmacologically activity of all phytochemical constituents from the *syzygium aromaticum*. It contain main chemical constituents of eugenol are called essential oil, light yellowish color, slightly aromatic odour. Mainly Indian spices and are used in as ayurvedic medicine. Cloves are shows such as the pharmacologically activity as anti-oxidant, anti-cancer, anti-microbial, anti-inflammatory, anti-pyretic, anti-viral, anti-diabetic, anesthetic, analgesic, anti-carcinogenic, antibacterial, antifungal, anti-biotic. Some other activities are shows masquito repellant and insecticidal. All the major activities of clove oil are explained in result have been reported regarding the various activities discussed in the review.

10. ACKNOWLEDGEMENT

The review work has been carried out at **Hygia Institute of Pharmaceutical Education and Research, Lucknow** Uttar Pradesh. We would like to pay my profound gratitude and appreciation to **Dr. Bhumika Yogi** and **Dr. Sujeet Kumar Gupta** for providing and the opportunity to work on such an exciting work. While carrying out review work my batchmate Miss. Smrati Chaudhari have always supported by their valuable suggestions. Well, it has been the immense faith and blessing of my guardian Mr. Vipin Yadav and Mr. Salman Ali always motivated me in difficult situations. Our sincere thanks also department of pharmaceutical chemistry.

11. REFERENCES

1. Hussain N, Trak Th. Medicinal Virtues And Phytochemical Constituents of Some of World Journal of Pharmaceutical Research Medicinal Virtues and Phytochemical Constituents of, October, 2019.
2. Cortés-Rojas DF, de Souza CRF, Oliveira WP. Clove (*Syzygium aromaticum*): A precious spice. *Asian Pac J Trop Biomed*, 2014; 4(2): 90–6.
3. Chaieb K, Hajlaoui H, Zmantar T, Et Al. The Chemical Composition and Biological Activity of Clove Essential Oil, *Eugenia caryophyllata* (*Syzygium aromaticum* L. Myrtaceae): A Short Review, 2007; 501-506.
4. Thangaselvabai T, Kennedy R, Joshua J, Jayasekar M. Clove (*Syzygium Aromaticum*) – The Spicy Flower Bud of Significance - A Review. *Agric Rev.*, 2010; 31(1): 40–7.
5. Jain A. International Journal Of Scientific Research Therapeutic And Medicinal Uses Of Lavanga-A Review Ayurveda Dr. Nidhi Garg *, 2019; 10: 8–10.
6. Yunusa S, Yusuf UM, Haruna I. Comparison of Essential Oil of Clove Buds Extracted Using Soxhlet and Ultrasonic-Assisted Extraction Method (Short Communication), 2018; 7: 1.
7. Khalil AA, Rahman UU, Khan MR, Sahar A, Mehmood T, Khan M. Essential oil eugenol: Sources, extraction techniques and nutraceutical perspectives. *RSC Adv*, 2017; 7(52): 32669–81.
8. Overly KR. Microwave-Assisted Isolation of Eugenol from Cloves. *J Chem Educ.*, 2019; 96(11): 2665–7.
9. Gokhale S.B, Kokate C.K, A Text Book of pharmacognosy, 21th Edition, Publication, Nirali Prakashan, 9C-46-48.
10. Kaur K, kaushal S, Phytochemistry and Pharmacological aspects of *Syzygium Aromaticum*: A review, 2018; 8(1): 398-406.
11. Shah B, Seth A. K. Text Book of Pharmacognosy and Phytochemistry, 2nd Edition, Publication, CBS Publishers and Distributors Pvt Ltd, 2014; 28-30.
12. Wallis. T. E. Text Book of Pharmacognosy, Fifth Edition, Published by S. K. Jain for CBS Publishers and Distributors, 173-174.
13. Evans. W. C, Trease Pharmacognosy, 15th Edition, Publication An imprint of Elsevier Limited, 274-275.
14. Kokate. C.K. Practical Pharmacognosy Edition-Fifth Edition, Publication Delhi Vallabh Prakashan, 48-51.
15. Khandelwal K.R, Practical Pharmacognosy Techniques and Experiments, 12th Edition,

- Publication, Published by Nirali Prakashan, 2004; 97-99.
16. Kumar N, A Text Book of Pharmacognosy, 1st Edition, Publication, Published by Virendra Kumar Arya for AITBS Publishers, India, 2010; 149-153.
 17. Handa S.S, A Text book of Pharmacognosy, 1st Edition, publication published by M. K. Jain for Vallabh Prakashan, 2001; 100-102.
 18. Kokate. C. K. Purohit. A. P, Pharmacognosy Edition-52nd, Publication- Nirali Prakashan, April, 2016; 373-376.
 19. Kaur K, Kaushal S, Rani R. Chemical Composition, Antioxidant and Antifungal Potential of Clove (*Syzygium aromaticum*) Essential Oil, its Major Compound and its Derivatives. J Essent Oil-Bearing Plants, 2019; 22(5): 1195–217.
 20. Mittal M, Gupta N, Parashar P, Mehra V, Khatri M. Phytochemical evaluation and pharmacological activity of *syzygium aromaticum*: A comprehensive review. Int J Pharm Pharm Sci., 2014; 6(8): 67–72.
 21. Marchese A, Barbieri R, Coppo E, Orhan IE, Daglia M, Nabavi SF, et al. Antimicrobial activity of eugenol and essential oils containing eugenol: A mechanistic viewpoint. Crit Rev Microbiol [Internet], 2017; 43(6): 668–89. Available from: <http://dx.doi.org/10.1080/1040841X.2017.1295225>
 22. Da Silva FFM, Monte FJQ, de Lemos TLG, do Nascimento PGG, de Medeiros Costa AK, de Paiva LMM. Eugenol derivatives: synthesis, characterization, and evaluation of antibacterial and antioxidant activities. Chem Cent J [Internet], 2018; 12(1): 1–9. Available from: <https://doi.org/10.1186/s13065-018-0407-4>
 23. Srinivasan S, Sathish G, Jayanthi M, Muthukumaran J, Muruganathan U, Ramachandran V. Ameliorating effect of eugenol on hyperglycemia by attenuating the key enzymes of glucose metabolism in streptozotocin-induced diabetic rats. Mol Cell Biochem, 2014; 385(1–2): 159–68.
 24. Mbaveng A. T, Kaete V, Therapeutic Potential against Metabolic Inflammatory Infectious and Systemic Diseases, 2017; 29.
 25. Hosseini M, Kamkar Asl M, Rakhshandeh H. Analgesic effect of clove essential oil in mice. Avicenna J Phytomedicine, 2011; 1(1): 1–6.
 26. Schnitzler P, Astani A, Reichling J. Screening for antiviral activities of isolated compounds from essential oils. Evidence-based Complement Altern Med., 2011; 2011.
 27. Pathirana HNKS, Wimalasena SHMP, DeSilva BCJ, Hossain S, Gang-Joon H. Antibacterial activity of clove essential oil and eugenol against fish pathogenic bacteria

- isolated from cultured olive flounder (*Paralichthys olivaceus*). *Slov Vet Res.*, 2019; 56(1): 31–8.
28. De Almeida AL, Caleffi-Ferracioli KR, De Scodro RB, Baldin VP, Montaholi DC, Spricigo LF, et al. Eugenol and derivatives activity against *Mycobacterium tuberculosis*, nontuberculous mycobacteria and other bacteria. *Future Microbiol*, 2019; 14(4): 331–44.
29. Olea AF, Bravo A, Martínez R, Thomas M, Sedan C, Espinoza L, et al. Antifungal activity of eugenol derivatives against *Botrytis cinerea*. *Molecules*, 2019; 24(7).
30. Dallmeier K, Carlini EA, Anesthetic, hypothermic, myorelaxant and anticonvulsant effects of synthetic eugenol derivatives and natural analogues. *Pharmacology*, 1981; 22: 113.