Fig. 1: (A) Leaves, (B) Inflorescence, (C) Stem and bark of *Acacia catechu* plant

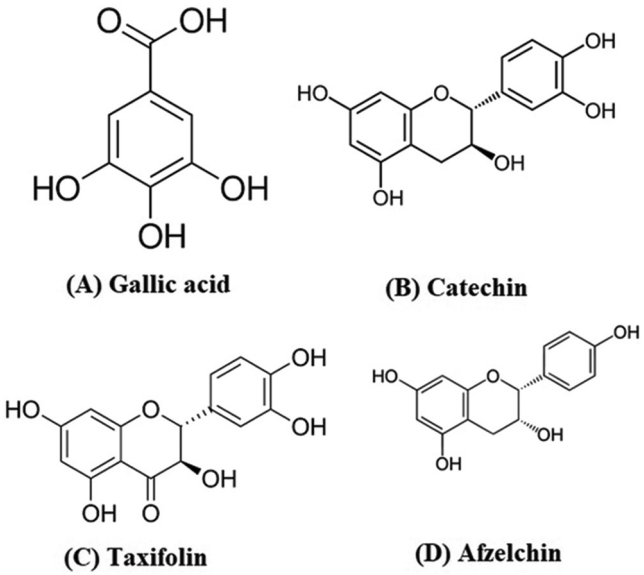

Fig. 2: Chemical structures of (A) Gallic acid, (B) Catechin, (C) Taxifolin, (D) Afzelchin

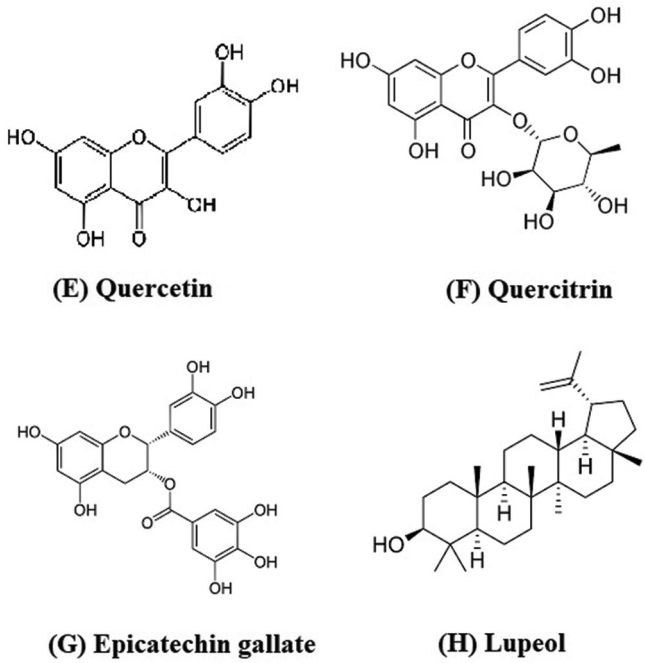

Fig. 3: Chemical Structures of (E) Quercetin, (F) Quercitrin, (G) Epicatechin gallate, (H) Lupeol

ANTIMICROBIAL ACTIVITIES OF *A. CATECHU* BARK

In vitro studies of *A. catechu* wild are reported to have a broad spectrum anti-microbial and anti-fungal activity [23,26]. In the last decade, a number studied have put data on the antibacterial activity of *Acacia* bark extract against some specific and some multi-drug resistant disease-causing bacteria [27-29]. Some recent scientific studies have revealed the antibacterial activity of different extracts of the heartwood of *A. catechu* and reported strong antibacterial and antifungal activities in different experimental models. In few *in-vitro* evaluations too, the same is found to be exhibiting the antibacterial activity against enteric pathogens [30,31]. In species-specific anti-bacterial assays both ethanolic and aqueous extracts of the heartwood of *A. catechu* were seen to be successfully effective against *Salmonella typhi*, *Shigella flexneri*, *Escherichia coli*, *Klebsiella pneumonia*, *Vibrio cholera*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*, etc bacterial cells [32-34]. In the same, the ethanolic extract was observed to be more efficient than the aqueous extract of the same also more efficient than the standard used [27,29,32]. Though, molecular level studies on the anti-microbial action of given bark extract is meager. But in few in-vitro antimicrobial assays the same; the phytochemical analysis showed that the alkaloids and carbohydrate substances are major bioactive compound work against pathogenic bacterial cells [33-35]. In one other research methanolic extract of *A. catechu* bark reported for its toxic effects against *Bacillus subtilis*, *S. aureus*, *S. typhi*, *E. coli*, *P. aeruginosa* and *Candida albicans* species of microorganisms [36]. To find out the responsible components of organic plant's extracts were separated by thin layer chromatography (TLC) and plant extracts were purified by column chromatography and were identified by Gas chromatography–mass spectrometry analysis. The analysis confirmed the presence of terpene, for example, camphor (nearly 76%) and phytol (nearly 28%) that to relate with its antibacterial and antifungal properties [28,32,36,37].

Table 1: Classification of *A. catechu*

Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Fabales
Family	Fabaceae
Genus	Acacia Mill.
Species	*A. catechu* wild – Black cutch

A. catechu: Acacia catechu

Phytochemical investigation of *A. catechu* wild shows the presence of alkaloids, flavonoids, glycosides, carbohydrates, phenolic compounds, different types of terpenes, saponins, steroids, and tannins which may be responsible for its anti-microbial activity. Methanolic extract of *A. catechu* wild (bark) has been known for antibacterial efficacy against both Gram-positive and Gram-negative bacteria. The same has also found to be helpful against *S. aureus* infection [22,25,30,34,38-40].

WOUND HEALING ACTIVITIES OF *A. CATECHU*

Wounds are actually disrupted by cellular or histological structures associated with loss of integrity and function. Though nature has given each living being the auto-power of regeneration, but sometimes severe damage in tissues and/or infection with some pathogen may cause deadly consequences [41]. In such cases, treatment with an anti- microbial agent

Table 2: The different categories, bioactive compounds and their medicinal properties are listed below

S. No.	Category of Phyto-chemical	Bioactive compounds	Related medicinal activities	References
1.	Flavanoids	Catechin, Epigallocatechin, Epicatechin gallate, Epicatechin, Epigallocatechin gallate, Eocatechin, Catecutannic acid, Quercetin, Quercitrin, Phloroglucinol, Procatechuic lupenone, Lupeol, Procyanidin AC Quercitrin acid, etc.	Antioxidative, Anti-inflammatory, Antipyretic, Anticancer, Anti-ulcer, Skin diseases, Melancholia, Conjunctivits, Diabetes, Hepato-protective activity, Cough, Pruritus, Leprosy, Body surface infection, Dysentery, Foul Ulcers Wound treatment, Haemorrages, Anaemia, Pharyngodynia	[16,30,44,48,64-49,71,72]
2.	Alkaloids	Taxifolin dihydrokaempferol, Kaempferol, Afzelchin gum, etc.	Antioxidative, Anti-inflammatory, Diabetes, Haemaptysis, Hepato-protective activity, Catarrah, Body surface infection, Leucoderma, Colon diseases, Diarrhea, Dysentery, Wound treatment, Anaemia, Pharyngodynia	[18,36,40-47,53-55,73,74]
3.	Glycosides	Poriferasterol, Poriferasterol acylglucosides etc.	Antioxidative, Anti-inflammatory, Antipyretic, Anticancer, Anti-ulcer, Skin diseases, Melancholia, Conjunctivits, Diabetes, Haemaptysis, Hepato-protective activity, Diarrhea, Anaemia, Pharyngodynia	[33-38,52,56-59,63,-66]
4.	Sugars	1,6;2,3-Dianhydro-4-O-Acetyl-Beta.-D-Gulopyranose, 1,6;3,4-Dianhydro-2-O-Acetyl-. Beta.-D-Galactopyranose, 4H-Pyran-4-One, 2,3-Dihydro-3,5-Dihydroxy-6-Methyl, 2-Furan carboxy Aldehyde, 5-(Hydroxymethyl), d-galactose, d-rhamnose, l-arabinose etc	Anaemia, Anticancer, Anti-inflammatory, Antioxidative, Anti-ulcer, Body surface infection, Catarrah, Conjunctivits, Dysentery, Hepato-protective activity, Leprosy, Skin diseases, Wound treatment, Haemorrages	[23,42,45-48,57,59,63-67,69,72-75]
5.	Tannins	Gallic acid, Phlobatannins etc	Antioxidative, Anti-inflammatory, Skin diseases, Melancholia, Conjunctivits, Diabetes, Haemaptysis, Hepato-protective activity, Catarrah, Cough, Leprosy, Body surface infection, Leucoderma, Helminthiasis, Diarrhea, Dysentery, Wound treatment, Fever, Anaemia	[33,42,45-48,57-59,63-67,69,70-75]

(*Contd...*)

Table 2: ***(Continued)***

S. No.	Category of Phyto-chemical	Bioactive compounds	Related medicinal activities	References
6.	Acidic Compounds	Acetic Acid, Caprylic acid -methyl ester, Lauric acid- methyl ester, Myristic acid- methyl ester, 2-Amino-Octadec-7-Ene-1,3-Diol Butane Boronate, Etc	Antioxidative, Anti-inflammatory, Antipyretic, Anticancer, Anti-ulcer, Skin diseases, Hepato-protective activity, Catarrah, Cough, Pruritus, Leprosy, Body surface infection, Leucoderma, Fever, Anaemia, Pharyngodynia	[43,46-49,52-59,63-67,69,72-77]
7.	Sterols	Poriferasterol, Poriferasterolacyl Glucosides, Aldobiuronic acid, etc.	Antioxidative, Anti-inflammatory, Anti-ulcer, Hepato-protective activity, Catarrah, Leucoderma, Colon diseases, Dysentery, Foul Ulcers Wound treatment, Haemorrages, Pharyngodynia	[19-23,42,45-48, 69,72-75]
8.	Other compounds	2-Ethyl-3- methyl-1-butene Essential oils, Naphtoquinones, Secondary amine, Phosphine, Phosphorous compounds, Sulfonyl chloride, Sulfone, Propanoic Acid-2-Oxo, etc.	Antioxidative, Anti-inflammatory, Conjunctivits, Diabetes, Catarrah, Cough, Body surface infection, Leucoderma, Colon diseases, Wound treatment	[18-23,42-47,55,58, 63-67,69,70-75]

is needed for the healing or survival of that organism. Earlier researches with different bark extract of *A. catechu* were seen to be effective treatment for wound healing [42,43]. Few investigations on wound healing efficiency of aqueous as well as alcoholic bark extracts of *A. catechu* in rats showed equivalent effectiveness as standard. In addition, results confirmed the presence of phyto-constituents like glycosides, carbohydrates, proteins, terpenes, saponins, phytosterols, tannins, and gums in the *A. catechu* bark. Both alcoholic and aqueous bark extracts of *A. catechu* are used to prepare ointment for wound healing [38,40-44]. The aqueous extract of *A. catechu* at 3–6% w/w has been reported to exhibit significant wound healing activity. Furthermore, a similar evaluation has been made with other varieties of Acacia stem bark. Here also some data showed that the wound healing potential is due to its bioactive components and were determined by preliminary phyto-chemical screening. In addition to this, in a number of studies, the formulation and ointment prepared from stem bark extracts in mice, rats, guinea pigs and human were seen significantly effective against microbial infected wounds [40,44-47].

Some workers have revealed the wound healing activity of combined therapy of hydroalcoholic extract of *A. catechu* and *Gymnema sylvestere* in albino mice and found this is occur due to free radical scavenging [48- 50]. Though, the mechanism and phyto-constitute involved in healing are not studied well. In addition to this the individual and additive impact of these phytochemicals is still not documented enough [30,51-53]. Though one study revealed that the results of TLC showed the presence of flavonoids may be the responsible factor for this. Similar results were obtained by other workers with combined treatment with Beeswax from *Apis mellifera*, *A. catechu* bark extract, the oil of *Sesamum indicum* and oil of *Azadirachta indica* [54-57]. This combination was seen to reduce inflammation at wounded area and seen to cure wound faster than single extract treatment in mice. The same researchers also showed that the anti-inflammatory and wound healing activity occur due to prostaglandin synthesis via cyclo-oxygenase pathway in animal models [49,52,58-60].

BIOACTIVE COMPONENTS OF *A. CATECHU*

The term "phyto-chemical" is generally used to describe chemicals obtained from plants that may improve the health status of organisms, but are not essential nutrients [45,61-64]. There are sufficient evidence to support the health benefits of the plant in the form of roots, stems, leaves, bark, and fruits [65]. Above mentioned activities of *A. catechu* bark extract were observed to be associated with the quality and quantity of secondary metabolites produced by plants [66,67]. These seem to exert definite physiological actions through either scavenging of disease-causing free radicals or by the destruction of infectious agents from the human body [68]. Plant-based drugs are complex mixtures of bioactive compounds. The information of the potential health benefits of individual phyto-chemical is linked to the information of the health effects of a drug that contains these phytochemical [69,70].

The main bioactive components isolated and studied of black catechu are flavonoids (catechin, rocatechin, epigallocatechin, epicatechin gallate, epicatechin, epigallocatechin gallate, catecutannic acid, quercitrin, quercetin, phloroglucinol, lupeol, procatechuic lupenone, procyanidin AC quercetin, quercitrin acid, etc), alkaloids (taxifolin, dihydrokaempferol, kaempferol, afzelchin gum), glycosides (poriferasterol, poriferasterol acylglucosides), tannins (gallic acid, phlobatannins), sugars (1,6;2,3-Dianhydro-4-O-Acetyl-beta-D-Gulopyranose, 1,6;3,4-Dianhydro-2-O-Acetyl-.Beta.-D-Galactopyranose, 4H-Pyran-4-One,2,3-Dihydro-3,5-Dihydroxy-6-Methyl, 2-Furan carboxy Aldehyde,5-(Hydroxymethyl),d-galactose, d-rhamnose and L-arabinose) [16,30,44,48,64-49,71].

A. catechu extracts have also played a role in chemistry, with various names of chemicals as catechin, catechol, and catecholamine being derived from bark. *A. catechu* is already been reported for the presence of caprylic acid methyl ester in about higher concentrations. The same has also been good source of Lauric acid, methyl ester (nearly about 28%). It has very high concentration (nearly 43%) of 2-Ethyl-3- methyl-1-butene and nearly 11% Myristic acid methyl ester which are known efficient bioactive compounds [72,73]. Some researchers carried out phytochemical studies of *A. catechu* and found poriferasterol, poriferasterolacyl glucosides, gallic acid, phlobatannins, d-galactose, aldobiuronic acid, d-rhamnose, and l-arabinose, etc [18,36,73,74].

DISCUSSION

Today, there are more than 121 pure chemical substances extracted from about 130 species of higher, used in the modern pharmacopeias throughout the world. Out of these, 89 plants derived drugs, currently used in modern medicine, were originally discovered through the study of traditional cures and plants folk knowledge of indigenous people [27,75-78]. Medicinal plants are valuable for human ailments because of the presence of phytochemicals, which are present in the form of secondary metabolites such as alkaloids, saponin, glycosides, lactones, steroids etc. Several medicinal plants and their products are still widely used by the traditional medical practitioners for curing various diseases in their day to day practice [76-79]. Though, thousands side effects of allopathic medicines have been documented till now and much more are coming in front, so the use of herbal medicines is safer, cheaper and easily available therapeutic agents [34,58,80]. *A. catechu* based treatment is one of them.

A. catechu wild has great importance in ayurvedic system of medicine due to its medicinal properties [81-83]. It is well known for its therapeutic uses in dermatological, cardiovascular and respiratory diseases. Further, due to the presence of great percentage of acidic compounds the same is also used to reduce pH that inhibits the growth of microbial cells [36,38,56,84]. Catechin Obtained from the same is known anti-oxidant and reported to exhibit *In vivo* antioxidant properties against free radical attack [67,73]. The bark of *A. catechu* is used as a potent wound healing medicine. The extract of the bark of the same has been reported to exhibit an astringent effect in different experimental models [37,45,78,80,85]. Furthermore, it also exhibits antimicrobial property which prevents the growth of microbes on wounds. From a dental perspective, when used externally as a powder, it cures bleeding gums. It is used with great benefit internally in the form of gargle to alleviate sore throat, halitosis and dental caries. The literature has shown that it is antimicrobial against several oral pathogens, namely *Streptococcus* and *Lactobacillus* species [40-46,67,86].

During the last several decades, natural products with antimicrobial effects were investigated in order to eliminate the use of synthetic antibiotics which cause the resistance of microorganisms and can exhibit side effects to human health. Plants extract from 157 families including, *A. catechu* have been reported to be active against microorganisms [43,64,68,71,85-87]. More so, *A. catechu* willd has also been reported for the synthesis and secretion of various active secondary metabolites which are already known for significant medicinal values, these are phenolic compound those serve as essential oils and also have significant insecticidal and antimicrobial activities. Because of such potential the same are routinely used in some pharmaceuticals, alternative medicines and natural therapies [28,36,52-56,87-90].

CONCLUSION

In conclusion, the bark extract of *A. catechu* with different solvents are seen to be effective against pathogenic microbial strains and same has also seen to effective to cure different physiological diseases like diabetes, cancer, ulcer, anemia, inflammation, leucoderma, colon problems etc. Here, we have also found that these protective effects of the same are correlated with the presence of bioactive components which are basically produced by plant as secondary metabolites. These finding revealed that the individual as well as formulation of the bark extract of *A. catechu* with other protective compounds may be a potent and natural way to cure wounds infections than artificial harmful chemicals. With limited and guided doses the same can also used to treat abdominal infections too in case of abdominal infections. Though, further studies are needed to demonstrate the actual mechanism of action of same at the molecular level.

AUTHORS CONTRIBUTION

I, Mrs. Archana Tiwari, assistant professor, Government P.G. College Damoh, District Damoh, Madhya Pradesh, India has done the above complete review work including data search, data collection, interpretation to conclude the whole work under the guidance and supervision of Professor (Dr.) Avinash Tiwari, Head, School of studies in Microbiology, Jiwaji University, Gwalior, (M.P.) India, under whom I am pursuing my present research work as Ph.D. candidate.

CONFLICTS OF INTERESTS

No conflict.

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Nil.

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