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Original article

Contemporary medicinal uses of ethnomedicinally important plant: Arjuna [*Terminalia arjuna* (Roxb.) Wight and Arn.]

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Abstract

Terminalia arjuna (Roxb.) Wight and Arn. (Arjuna tree) is one of the important medicinal plants which belong to the family Combertaceae. This plant is widely distributed in Asia, especially in India and Bangladesh, and has been used extensively in modern herbal preparations related to heart diseases. In ethnobotanical perspective, this plant has great significance and utilized variously by the indigenous tribe. Through, this article is an attempt, has been made to recapitulate its ethnobotanical importances, current uses in healthcare in treatment of various aliments, and its future prospective. The potential of this plant is also highlighted in the context of genetic engineering and tissue culture approaches through that the production of plant cell products can be improved many folds without any serious loss to the diversity of this imperative medicinal plant.

Keywords: *Terminalia arjuna* (Roxb.) Wight and Arn., ethnobotany, medicinal plant, tribes

1. Introduction

Ethnobotany is the study of useful relationships (both abstract and concrete) between human beings and vegetation in their ambient environment, involving their medicinal and other uses (Harshberger, 1896). Indigenous populace has great knowledge about their surrounding plants. They cultivate and pass the knowledge through ethnobotanists around the world for the purpose of different applications, particularly in modern medicine (Pandey and Tripathi, 2017). Therefore, it is essential to preserve this indigenous knowledge regarding those plants having traditional medicinal uses by proper documentation, identification of plant species used, and herbal preparation. One such genus is *Terminalia* which contains many species of medicinal (Majeed, 2017), ornamental, economic and cultural importance. Among them, Arjuna, *i.e.*, *Terminalia arjuna* (Roxb.) Wight and Arn. (Family Combertaceae) is most popular and used frequently in many ayurvedic preparations (Alam and Sharma, 2013; Anjaneyulu and Giri, 2018). Every part of this plant contains medicinal value, consequently, Arjuna hold a remarkable position in both Ayurvedic, Siddha and Unani systems of medicine. In the era of phytopharmaceuticals, this plant has special mention in developing future strategies (Nooreen *et al*., 2018).

During the course of this study, all available information on *T. arjuna* was collected from print and electronic resources along with the rigorous library search for those articles which are available in local books.

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2. Occurrences and botanical description

Terminalia consists of nearly 200 species, distributed around the world. About 24 species have been observed from various parts of India. *T. arjuna* is invariably found in Uttar Pradesh, Madhya Pradesh, Delhi, South Bihar and other areas, mainly near ponds, river and bank of streams. It is a large, perennial tree having horizontal spreading crown and drooping branches. The bark is smooth and appears slightly as pinkish-grey in colour. Leaves of *T. arjuna* are sub-opposite, oblong, glabrous, margin may be acute or obtuse at apex. Flowers are whitish or yellowish in colour that is found in clusters (Figure 1) (Amalraj and Gopi, 2017).

Figure 1: *Terminalia arjuna* blossoming branchlet (**Source:** Pitchandikulam Forest Virtual Herbarium).

3. Ethnomedicinal worth

The tribes of India, *viz*., Khasis, Garasia, Sahariya, Dhanka, Knjar, Kothagiri, Karbis, Bhil, Meena, Kalbelia, Oraon, Munda, Kora, Sabara, Gand, Bhumia, Kol, Halba, Yanadi, Irular, Gujjar, Maria, Kathodia, Damor, *etc*., have been using Arjuna for various purposes,

especially for the treatment of various diseases. The indigenous medicine-men have mentioned various preparations of this plant (Sharma and Alam, 2018). In ancient literature, *T. arjuna* mentioned in Ayurveda in the seventh century, as its bark is used for the treatment of heart diseases (Hebbani *et al*., 2015). Traditionally, the bark of *T. arjuna* is used as milk decoction. Bark is used for the purpose of cardioprotection and hypertension. It is also used to decrease blood pressure, cholesterol level, pulse rate and increase aerobic exercise capacity. The powder of *T. arjuna* is used on wounds, to treat haemorrhages, ulcers, tumours, skin and gynaecological problems. It is also used to cure earaches, dysentery, sexual diseases, and urinary tract infections (Kaur, 2015).

3.1 Ethnomedicinal uses

The bark has been used in ulcers, fracture, leucorrhea, anaemia, diabetes, cirrhosis and cardiopathy (Warrier *et al*., 2014). Chakradatta was a great physician that recommended that the decoction of bark mixed among milk, ghee or butter has been given as cardioprotective remedy (Chopra *et al*., 1958). Bark decoction has been used for ulcer wash whereas bark ashes applied in snakebite or scorpion sting (Jain *et al.,* 2009). In Tamil Nadu, the traditional therapists use *T. arjuna* bark powder which is boiled along with water and inhaled it for the treatment of headache and also used to kill the worms present in the teeth. Fruit paste is applied to cure the wound (Muthu *et al.,* 2006). In Malabar tribes of Kerala, freshly prepared leaf juice of *T. arjuna* is used to treat the pain of the ear and bark powder is used for heart aliments treatment (Yesodharan and Sujana, 2007). Tribal in Sundargarh (in Odisha), they use dry bark powder of *T. arjuna* with water of washed rice for the treatment of bloody urine. Among the tribes of Malkangiri, the fresh bark of *T. arjuna* chew and shallow the juice, which act as an antacid (Prusti and Behera, 2007).

4. Phytochemistry

All parts of *T. arjuna* contain major chemical constituents. The bark contains important chemical constituent; flavones, arjunolone, terpenes, and their glycosides, arjungenin, friedelin, arjunin, arjunectine, arjun, glycosides I, II, III, arjunoside II, arjunolic acid, oleanolic acid, arjunic acid, ellagic acid and large amount of calcium salts have been isolated from bark (Gupta *et al.,* 2018). The roots contain triterpenoids, glycosides and β- sitosterol as major chemical constituents. While β-sitosterol, flavonoids, alkaloids, tannins and steroids are major chemical constituent obtained from the leaves. Some amino acids like tryptophan, tyrosine, histidine and cysteine are also the main ingredients in *T. arjuna* (Amalraj and Gopi, 2017).

5. Role of *T. arjuna* in various diseases

Major active constituents of *T. arjuna*, namely; gallic acid, arjunolic acid, β-sitosterol, terminic acid pyrocatechols, calcium, magnesium, zinc and copper. They all have medicinal value on pharmacological agents as anticancer, antimicrobial, antiacne, antidiabetic, antianthelmintic, anticholinesterase, anti-inflammatory, antioxidant, antiasthmatic as well as wound healing, cadioprotective and insecticidal activities. *T. arjuna* is usually used to cure cancer, cardiomyopathy and hypertension. It is also used to reduce the effect of stress and anxiety, antimutagenic, hypolipdemic, antioxidant and hypocholesterdamic. It also has the ability to protect the kidney and liver tissue against CCl_4 induces oxidative stress (Vaseem, 2014).

5.1 Experimental evidences

5.1.1 Effect on CCl_4 induced hepatic and renal disorders

Carbon tetrachloride induces hepatotoxicity and nephrotoxicity that leads to liver and kidney damage by the production of free radical. Metabolic activation of carbon tetrachloride leads to the formation of free radicals trichloromethane and chlorine. Free radical trichloromethane reacts with oxygen and form more reactive free radical $CCl_3OO^{\cdot}$. This may lead to oxidative stress that causes a decrease in intracellular concentration of glutathione and reduces activities of antioxidants like superoxide dismutase, catalase and decrease detoxification generated by glutathione-s-transferase. Decrease in activities of antioxidants lead to increase in lipid peroxidation in livers and kidneys. Aqueous extract of *T. arjuna* contains antioxidant property that protect the antioxidant machineries of kidney and liver by increasing levels of superoxide dismutase, catalase, glutathione-s-transferase and decrease level of lipid peroxidation (Manna *et al.,* 2006).

5.1.2 Effect on diclofenac sodium induced gastric ulcer

Diclofenac sodium is an NSAID that used to cure osteoarthritis and rheumatoid, but it also produces toxic effects that cause bleeding, ulceration and perforation of stomach. 10-25% of patients are affected by gastric ulceration during chronic administration of non-steroidal anti-inflammatory drugs. *T. arjuna* is used to cure ulcer that would be produced by non-steroidal anti-inflammatory drugs. *T. arjuna* contains various components such as tannin, saponin, steroid, phenol, flavonoid, *etc*. Tannin has protein precipitating and vasoconstriction property that inhibit ulcer development. And, flavonoid reduces lesions that are formed by necrotic agents. During gastric ulcer treatment with *T. arjuna*, acid is the main agent in the occurrence of acute and chronic gastric mucosal lesions. It has been studied that during the treatment of gastric ulcer with *T. arjuna*, decrease in acidity and increase in pH, results in highly favourable gastro-protection and antiulcer effect. Oxygen free radical is another important factor, causes lipid peroxidation that result in membrane fluidity and enhance the influx of calcium ion. Scavenging free radical plays an important role in healing ulcer present in gastric. Some saponins also show ulcer-healing property by forming a protective mucous barrier on gastric mucosa (Devi *et al*., 2007).

5.1.3 Effect on arsenic-induced hepatic disorder of arjunolic acid

Arsenic affects nearly all organs, but mostly cause hepatic damage. Arsenic produces reactive oxygen species such as superoxide anion radical, hydroxyl radical and hydrogen peroxide. These free radical results in the increase in lipid peroxidation, deoxyribonucleic acid fragmentation, protein carbonyl content and decrease the level of antioxidants such as thiols and glutathione. Pre-treatment with arjunolic acid prevents all these alternations without any side effects. Arsenic and arjunolic acid formed a five-membered chelate complex that suppressed arsenic-induced toxicity. Arjunolic acid contains polyhydroxyl groups that act as free-radical scavenging property and interacts with ROS, and thus, cells are protected from oxidative stress. Arjunolic acid plays a preventive role against hepatic disorders probably due to its chelating as well as free-radical scavenging property (Manna *et al*., 2007).

5.1.4 Effect on arsenic-induced testicular oxidative stress by arjunolic acid

Arsenic causes significant oxidative stress and severe damage to the testes. This damage may be prevented by arjunolic acid. Arjunolic acid possesses radical scavenging activity and also prevents alternation to cellular antioxidant power caused by arsenic. When testicular epidermal cells are treated with arsenic then these epidermal cells cause necrosis and degeneration of seminiferous tubules. Arsenic intoxication leads to increase lipid peroxidation in the testes. Before arsenic intoxication, the treatment of arjunolic acid maintains structurally and functionally active seminiferous tubules more or less similar to those of normal control. Vitamin C also prevents testicular oxidative damage due to its free radical scavenging property. Arsenic and arjunolic acid formed five-membered chelate complex that suppresses arsenic-induced toxicity. The five-membered chelate complex protects the organ from arsenic-induced toxicity (Manna *et al*., 2008).

5.1.5 Effect on adriamycin-induced DNA damage

Anthracycline is anticancer drug that inhibits DNA and RNA synthesis. This drug is used to cure many types of cancer. Anthracycline insert between base pairs of DNA/RNA strand, so inhibit their synthesis, but it shows some side effects. Adriamycin is useful as well as harmful for our body. It is useful to cure different types of cancer and it is harmful because it induces cell toxicity due to chronic administration of anthracyclines. It has been mentioned that many plant products contain strong anticancer product without any side effect. Adriamycin showed many cellular effects such as it forms stable complexes with ferric iron, then complex react with O_2 to form hydrogen peroxide, superoxide anion and hydroxyl free radical. These free radical leads to DNA damage. Antioxidants act as scavengers against reactive free radicals that result in decrease the harmful effects of adriamycin. *T. arjuna* contain compounds that have strong antioxidant property. So, *T. arjuna* extract scavenge superoxide and hydroxyl free radical and lipid peroxidase (Reddy *et al*., 2008).

5.1.6 Role as antioxidant defence system in cancer

The increase in ROS leads to the development of cancer. Reactive oxygen species are formed during aerobic metabolism. The constant formation of reactive oxygen species is equated by the antioxidant defence system. ROS cause various cellular aberrations, including damage of protein, deactivation of enzymes, DNA alteration and lipid peroxidation. So, cellular health is maintained by scavenging the multiple types of free radicals. Action of antioxidant occurs by improving the activities of antioxidant enzymes like catalase, superoxide dismutase and glutathione-s-transferase. Catalase is a heme-containing enzyme that provides an antioxidant defence system by degrading hydrogen peroxide to oxygen and water and also provides antioxidant defence system by oxidation of low molecular weight alcohols to aldehyde and water. And, superoxide dismutase catalyze dismutation of superoxide radical into hydrogen peroxide and this hydrogen peroxide is further catalyze by catalase and glutathione peroxide into water and oxygen. Glutathione is a thiol-containing molecule that helps in the protection of tissue from the toxic effects of xenobiotics and endogenous electrophiles. Glutathione-s-transferase encourages binding of electrophilic substrate with glutathione rather than with other cellular nucleophile. Glutathione-s-transferase helps in lowering of oxidative stress **(**Verma and Vinayak, 2009).

5.1.7 Effect on both calcium phosphate and calcium oxalate crystal formation

Aqueous extract of *T. arjuna* bark has the potential to inhibit the formation of both calcium phosphate and calcium oxalate crystals *in vitro*. About 75% of all urinary calculi have calcium-containing stones, which may be in the form of pure calcium oxalate (50%) or calcium phosphate (5%) or a mixture of both (45%). The formation of bone and teeth takes place in the controlled biological situation. Uncontrolled pathological crystallization occurs due to the formation of precipitates in the body by supersaturated the solvents. The formation of precipitates in the body is called as kidney stones (urolithiasis). Precipitation of ion takes place when ionic product becomes greater than solubility product. Many factors affect the formation of kidney stone. Kidney stones may occur due to the concentration of urine. Concentrated urine leads to the formation of crystals by the calcium oxalate and calcium phosphate or other chemicals. The crystal formation occurs on the inner surfaces of the kidney, subsequently, these crystals may combine to form a small hard mass called stone. Secondary metabolites, mainly saponin present in the aqueous extract of *T. arjuna* that interfere with the growth of calcium oxalate and phosphate and thus, inhibit their growth (Chaudhary *et al*., 2010).

5.1.8 Effect on ear infection

Ear infection is generally caused by the fungal pathogens like *Aspergillus niger, Aspergillus flavus* and bacterial pathogens like *Escherichia coli, Streptococcus pneumoniae, Streptococcus aureus*. Multidrug-resistant pathogens become hard to treat with certain antibiotics. Bacteria develop resistance against antimicrobial drug. Failure of antimicrobial drug leads to screening of various medicinal plants for their potential antimicrobial activity and development of new antimicrobials by drug companies. *T. arjuna* contain several secondary metabolites that have good antibacterial and antifungal property. It has been observed that the leaves and bark extracts of *T. arjuna* contain antibacterial activity against ear infection which can be observed by the formation of inhibition zones of both gram-positive and gram-negative bacteria (Aneja *et al.,* 2012).

5.1.9 Effect on caffeine induced coronary heart disease

Caffeine is a trimethylxanthine that is found mainly in coffee, tea, kola nuts, chocolate, soda beverages, drugs, *etc*. Caffeine consumption increases urinary calcium levels and also causes irregular heart beat in many people. It also crosses the placenta and blood brain barriers. High caffeine intake in pregnancy may lead to low birth weight and also leads to doubles the risk and spontaneous abortion. It is absorbed by the stomach and small intestine and their metabolism occur in the liver by the cytochrome P450 oxidase enzyme system that results in the formation of three metabolite products like paraxanthine, theobromine and theophylline. These may further metabolize and then excreted in urine. It has been reported that the increase in cholesterol concentration in blood that also increase the risk of coronary heart disease. It has been experimentally studied the benefits of *T. arjuna* in the treatment of coronary artery disease, heart failure and hypercholesterolemia (Asha and Taju, 2012).

5.1.10 Hypoglycemic effects on normal and alloxan-induced noninsulin-dependent diabetes mellitus albino rats

In diabetic patients, the glycation reaction occurs in various tissues like β-cells of the pancreas that leads to the formation of ROS. The

produced reactive oxygen species cause the development of diabetes related complication. Antioxidant preserves the function of β-cells in diabetes. Alloxan is a cytotoxic agent that induces chemical diabetes by damaging the insulin secreting cells. Alloxan diabetes occurs due to destruction of islet of langerhans of the pancreas and β- cells of the pancreas also affected that result in the formation of redox cycle for the generation of ROS, superoxide radicals and hydrogen peroxide. The ROS cause DNA cleavage and protein fragmentation of pancreatic islet cells that result in cell death and apoptosis. Bark of *T. arjuna* contains active constituents that have strong antioxidant activity and posses antidiabetic effect. Flavonoid content is useful to regenerate the damaged β-cells of the pancreas and reduce the blood sugar level in diabetic rat **(**Barman and Das, 2012).

5.1.11 Study on osteopotential activity of *T. arjuna* bark extract incorporated bone substitute

They conclude that paste of *T. arjuna* bark is used to cure bone fractured of human as well as animals. It is considered that if bark paste is used in fractured bones, then the regeneration occurs at a faster rate. Bark decoction is used for therapeutic beneficiary to reduce the inflammation and pain. Bark is also used as a cardioprotective agent for the treatment of ischaemic heart disease and hypertension. The bone damage leads to the destruction of huge portions of the bone that creates size defect and this defect needs bone substitutes that help in regeneration. It was studied that when bioactive material placed in simulated body fluids (SBFs), then bone apatite formed only from bioactive materials on the bone surface. Along with the bioactive materials, biphasic-calcium phosphate (BCP) is also used as it has flexible property. Casein is a family of related phosphoproteins which is insoluble in water and contains 20% milk protein. Casein phosphopeptides (CPPs) is used to steady the formless phase of calcium phosphate by making casein phospholipid-calcium phosphate complexes and this complex act as anticariogenic potential (Figure 2).

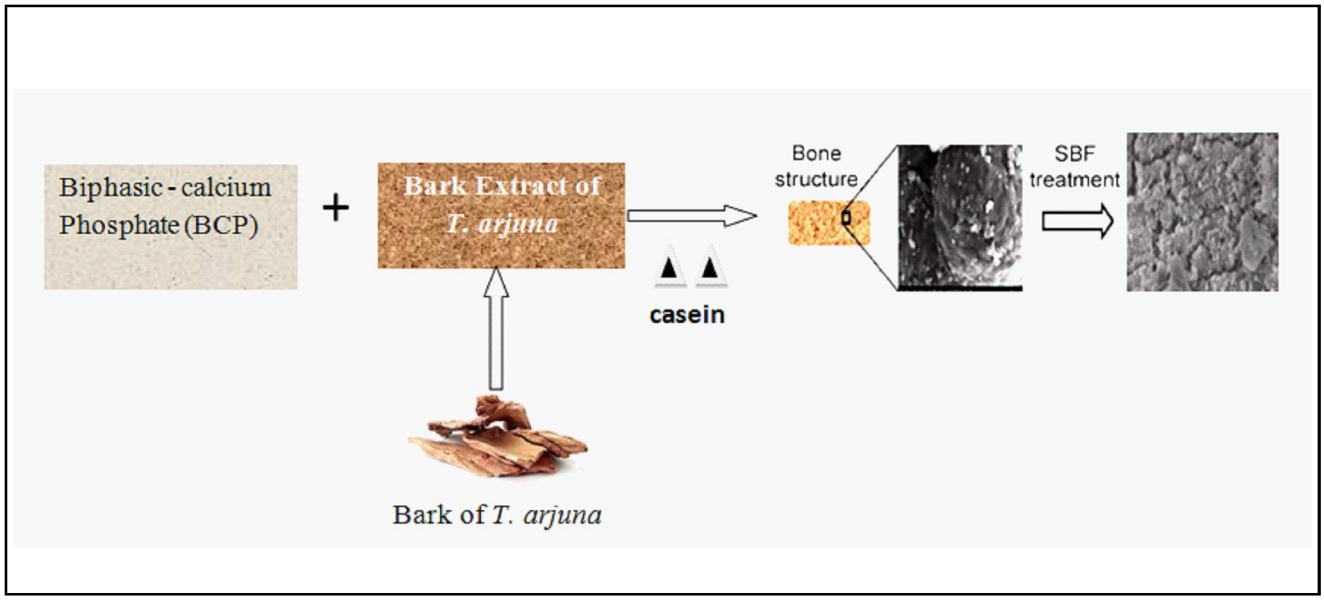

Figure 2: Analysis of the osteopotential activity of *T. arjuna* bark extract incorporated bone substitute (Krithiga *et al.*, 2014).

New bone formation was prepared by using biphasic-calcium phosphate and ethanolic bark extract of *T. arjuna* along with casein (Krithiga *et al.*, 2014).

5.1.12 Effect on human breast cancer cell lines (MCF-7)

Flavonoids content present in the methanolic extract of *T. arjuna* is responsible for its antiproliferative activity. So, it is the most effective anticancer agent. Flavonoid may be degraded in the gastrointestinal tract after absorption that results in poor bioavailability. Bioavailability of herbal drug can be enhanced by phytosome which is made by phospholipid and natural active ingredient. In this phytosome, hydrophilic constituents of herbs are surrounded or bound by phospholipids. These lipophilic complexes increase the absorption. *T. arjuna* bark extract and its phytosomes show antiproliferatiive activity on human breast cancer cell line MCF-7. Hydrolysable tannin named casuarinin that is isolated from the bark of *T. arjuna*. Casuarinin inhibit breast cancer cell growth by inducing apoptosis and cell cycle arrest in human breast adenocarcinoma MCF-7 cells. Methanolic extract of *T. arjuna* bark exhibit antimutagenic activity and also inhibit the growth of human fibroblasts, osteocarcinoma and glioblastoma (Sharma *et al.*, 2015).

5.1.13 Compare the effect of *T. arjuna* with rosuvastatin on TC and LDL-C

Rosuvastatin is used to reduce LDL and increase HDL. Dyslipidemia happen when someone has abnormal levels of lipid in the blood. It increases the high level of lipid or a low HDL cholesterol level. For the treatment of dyslipidemia disease, rosuvastatin is mainly used. But these types of drugs have side effect while few side effects have been observed when using natural products. *T. arjuna* contain hypocholesterolemic activities. *T. arjuna* show more decrease in TC and LDL-C levels than the rosuvastatin (Figures 3a, b).

For TC, it was observed that patient treated with rosuvastatin show decrease of 10.10%, 19.42% and 24.74% in 4, 8 and 12 weeks while patients treated with *T. arjuna* show decrease of 14.06%, 24.73% and 27.89% in 4, 8 and 12 weeks, respectively.

For LDL-cholesterol level, the patient treated with rosuvastatin show decrease of 9.48%, 16.02% and 19.93% in 4, 8 and 12 weeks while patients treated with *T. arjuna* show reduction of 11.25%, 19.73% and 23.15% in low-density lipoprotein level in 4, 8 and 12 weeks respectively. Thus, it concluded that the *T. arjuna* is more effective in dyslipidemic patients (Prakash *et al*., 2016).

5.1.14 Improve lipid oxidative stability and storage quality of muscle foods

Meat and meat products contain high amount of lipids that are highly susceptible to oxidation that is a major cause of quality loss during storage. The product of lipid oxidation may react with proteins, peptides and amino acids, and allow the oxidation of proteins causing changes in their structure that leads to the loss of their biological function. So, change in lipid oxidation is important concern for meat industry. In meat and meat product, lipid oxidation is reduced by the presence of antioxidants that are naturally present in high amount in some plant. *T. arjuna* contain major active constituents like alkaloids, tannins, flavonoids, triterpenoids, saponins and reducing sugar. These constituents may be used as natural preservative in the food industry (Kalem *et al*., 2017).

5.1.15 Effect on oxalate injured renal epithelial cells

It has been reported that bark extract of *T. arjuna* inhibits the precipitation and growth of calcium oxalate crystals. Renal epithelial cells play an active role in making the condition that develops stones in the kidney. When renal epithelial cells are exposed to high level of oxalate or calcium oxalate monohydrate crystals, then it leads to a variety of changes and cause injury to renal epithelial cells, which then cause cell death. The calcium oxalate crystal show tightly adhering to renal cells. When renal cells are treated with the bark extracts of *T. arjuna*, then leads to protection and reduced the injury by breakdown the interaction of calcium oxalate with cell surface. This leads to increase the number of viable cells and loss of crystal adherence. It also demonstrated that the cells that are exposed to oxalate cause induction of apoptosis, which results in morphological changes such as irregular, shape, apoptotic bodies, membrane blebbing and condensed or fragmented chromatin that leads to increased cell death. Cells treated with *T. arjuna* show cytoprotective potential that leads to increase in number of viable cells with intact cellular membrane and fewer apoptotic bodies (Mittal *et al.*, 2017).

5.1.16 Effect on human sperm DNA damage

Cigarettes harm the body machinery by producing strains, obesity, blood pressure, cholesterol, hypertension, zinc deficiency, diabetes, mellitus, and also harms the reproductive potential of both men and women. Due to their consumption, cigarette originated oxidants increase the ROS that lower the integrity of DNA and reduce semen quality. Increase in reactive oxygen species leads to the reduction in antioxidant that result in an imbalance between antioxidant and free radical in semen. In cigarette smokers, any type of DNA injury occurs in human sperms due to reactive oxygen species. Younger generation that smokers may contain partial DNA damaged in sperm that cause cancer. Some medicinal plants are used to inhibit DNA damage and also used to cure free radical induced damages. *T. arjuna* contain antioxidants, which are biological defenses and consist of flavonoids, phenolic, carotenoids, high amount of trace elements like zinc and selenium. Antioxidants act as scavengers against reactive oxygen species that donates its electron to ROS. *T. arjuna* contain higher zinc potential that decreases reproductive metal toxicants like cadmium and lead (Parameswari *et al.*, 2017).

6. Effect of toxicology and hematology on a freshwater catfish, *Heteropneustes fossilis*

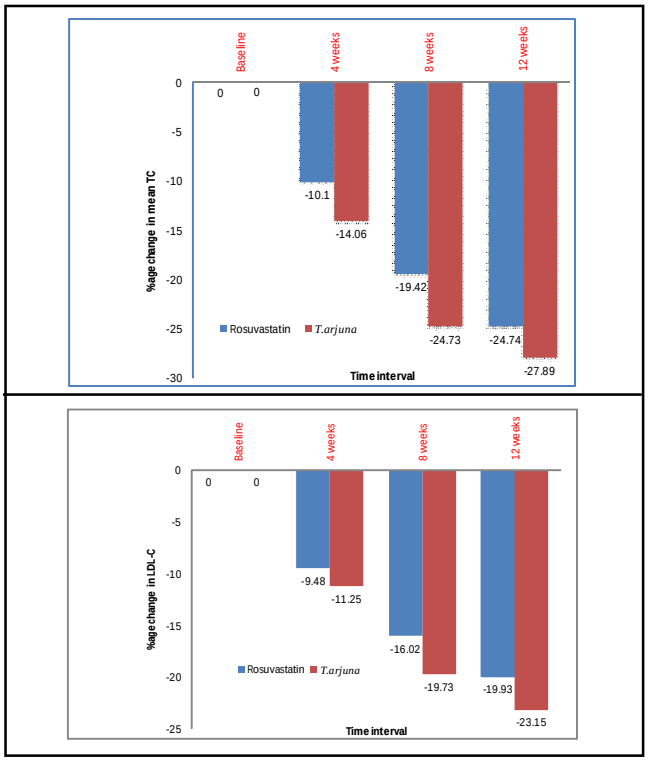

Figure 3: **(a)** Percentage change in total cholesterol, (b). Percentage change in LDL-cholesterol (Prakash *et al.*, 2016).

Heteropneustes fossilis has been used as a model fish due to easily available and survive in laboratory condition. Catfish is used to estimate toxicity of several chemical and botanical toxicants. Predatory fishes create serious problem due to their faster growth and their carnivorous nature. They adversely affect production and economy of fish farms. They create problems due to their habitat as they are obscured in the mud for longer period and make difficult to catch them by dragging. *T. arjuna* show piscicidal activity which causes the toxicological effect on fish and leads to death. Plant extracts are more useful because of eco-friendly, easily availability, high efficiency, quick biodegradability and decrease toxicity to non-targeted animals. The toxicity level as well as piscicidal activity can be subsequently calculated by median lethal concentration (LC_{50}). For *H. fossilis*, the LC_{50} value of *T. arjuna* bark extract ranges between 12.7 mg/l for 24 h and 4.71 mg/l for 96 hours. The value of LC_{50} varies according to the fish species. Acute toxicity test was carried out to check the toxicological effect on fish hematology. Hematological parameters are used to observe the fish condition in aquaculture. In fishes, haemoglobin content, hematocrit (Hct) and total RBCs count decrease when treated with *T. arjuna*.

Decrease in haemoglobin content leads to interruption of oxygen supply to tissue and create anemic condition. Anemia in fish blood leads to physiological changes such as damage of mature RBCs, inhibition of erythropoiesis, disruption of hemo-synthesis and iron-synthesizing mechanism. The MCV and MCH level increase while MCHC level decrease that indicates the swelling in RBCs. The decrease in MCHC level has the quality to release young RBCs having lower haemoglobin into circulation. In toxic condition, lymphomyeloid tissue increased the release of lymphocytes that act as a defence mechanism to bear and beat the situation which increase WBCs content. Due to these fluctuations, the extract considered as piscicide.

Therefore, *T. arjuna* bark extract was considered to be poison to control unwanted fishes from aquaculture (Suely *et al*., 2015).

7. Conclusion

Terminalia arjuna (Roxb.) Wight & Arn., a traditional medicinal plant which has been used to cure numerous diseases from ancient time. Almost all parts are used for medicinal purpose. Various parts of *T. arjuna* have been used directly by indigenous people to cure various diseases like headache, ulcers, snakebite, ear pain, eye infection, cough, cardiac pain, chest pain, bone fracture, *etc*. The plant contains bioactive molecule such as tannin, saponins, flavonoids, ellagic acid, arjunilic acid, natural oxidants, phytosterol, large amount of minerals like magnesium, zinc, calcium and cobalt and reducing sugar. It has been concluded that *T. arjuna a*contains properties like cardiotonic, hypatoprotective, immunomodulatory, insecticidal, antioxidant, antidysenteric, antidiabetic, antimicrobial, antimutagenic properties. It is mostly used to cure heart related diseases. As we know that *T. arjuna* contain many photochemical. So, it can be used for making many medicines. Most of the researches have been done on the bark of *T. arjuna*. We can obtain novel drugs from its other parts also. Free radicals have attracted a great deal of attention in the recent year. The novel and upcoming approaches such as gene therapy for making more useful, fresh phytochemicals including antioxidants would enable the genetic engineers to accomplish the task in this direction. New and improved varieties of *Terminalia* can be developed with the help genetic engineering and various tissue culture techniques especially somatic embryogenesis, for Ayurvedic point of view for their better utilization in contemporary pharmacognosy.

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Conflict of interest

The authors declare that no conflict of interest exists in the course of conducting this research. All authors had final decision regarding the manuscript and the decision to submit the findings for publication.

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