Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol.13, No.1, 2023

Antioxidant Potentials and Environmental Application of Tamarindus Indica Plant: A Brief Narrative Review

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Abstract
Different potentials has been devoted to most of the abundant and under-utilized plants found in Africa. This characteristic properties can be harness and channel to aid environmental, economic and social development. *Tamarindus indica* is one of the most commonly under-utilized plant materials with a number of reported biological and environmental relevance. In this mini review, we reported on antioxidant potentials and environmental role associated with *tamarindus indica* which might be due to its vast phytochemical profile. The aim of the work was to unravel the applicability of antioxidant possession of *Tamarindus indica* in the field of environmental health and remediation. About sixty one (61) publications out of two hundreds (200) sourced from various databases were consulted. The articles were screened based on their bearing to the areas concerned this report. Numerous researchers revealed antioxidant capacity, phenolics and ascorbic acid content of different parts of tamarind to be significantly appreciative. This property shows a strong association with the vast amount of phytochemical confined in this plant. Antioxidant property in *Tamarindus indica* might serve a driving force in many of its displayed biologicals potentials. Thus, *tamarindus indica* could also serve a reasonably in the field of environmental health and safety due to their abundance and less utilization.
Keywords: Tamarind; antioxidants; phytochemicals; environment; remediation
DOI: 10.7176/JEES/13-1-02
Publication date: January 31st 2023

1. Introduction

Tamarindus indica L. is a perennial evergreen tree belong to the family *Fabaceae or Leguminosae,* subfamily *Caesalpinioideae*. It is cultivated worldwide, naturalized partly in the tropics and subtropics[1][2]. Two types of tamarind includes the 'sour' which is the most common and 'sweet' found mostly in Thailand, both can be eaten fresh (unripe/ripe) or as a processed product[3][4]. Tamarind has different local names based on cultivating countries as indicated [Table 1] [5]. Mexico and Costa Rica are the largest producers of tamarind followed by Asian countries such as India, Thailand, Bangladesh, Sri Lanka and Indonesia[6]. It is widely used among the local people in Africa but not produce on a commercial scale[6]. The plant grow wild on wastelands, backyards and roadsides in the Savannah region of Nigeria[7]. In sub-sahara Africa, this indigenous plant contributes to food security and ecosystem stability[8]. *Tamarindus indica* was used for food, medicinal, cultural, social, environmental amelioration and income generation purposes[8]. This plant was re-counted to possess great potential to address various nutritional, health, socioeconomic and environmental constraints[8][9]. Different parts of this plants viz. pulp, fruits, seeds, leaves, flowers and bark have been used in traditional medicine for various clinical conditions[1][5][9]. Research without number were documented on nutritive value of several part of this plant with high carbohydrate, protein, fat and minerals content[6][7][10][11][12]. Traditional medicinal role of tamarind validated in the light of scientific research were also reported in the literature[13][14]. This review aimed at outlining some reported potential antioxidant phytochemicals found in various part of *Tamarindus indica* and correspondingly highlight its possible application in environmental research.

1.2 Botanical Classification (Isha and Parle[5], Sarker[15], Zohrameen *et al.*,[3], Santosh *et al.*,[16]).

Kingdom: Plantae (Plants)
Sub kingdom: Tracheobionta (Vascular plants)
Super division: Spermatophyta (Seed plants)
Division: Magnoliophyta (Flowering plants)
Class: Magnoliopsida (Dicotyledons)
Subclass: Rosidae
Superorder: Rosanae
Order: Fabales
Family: Fabaceae (Pea family)
Subfamily: Caesalpinioideae
Genus: Tamarindus L. (Tamarind)
Species: T. indica

Tribe: Detarieae
Binomial name: *Tamarindus indica* L.

Table 1. Common Names of Tamarind Based on Tribe / Geographical Location.

Country/ Language	Common/ Vernacular Names	Country/ Language	Common/ Vernacular Names
Arabic	Sbar, Tamar hindi	Malay	Asam jawa, asam kuning
Assamese	Teteli	Malayalam	Puli
Bengali	Tentul	Marathi	Chinch
Burmese	Me-gyi-thi	Oriya	Tentuli, kainya
Chinese	Asam koh	Pharm	Pulpa Tamarindorum
Danish	Tamarind	Philippines	Sampalok, (tagalog), Kalamagi (Bisaya)
Dutch	Tamarinde, Indische dadel, Assem	Portuguese	Tamarindo
English	Indian date	Punjabi	Imbli
Esperanto	Tamarindo	Russian	Indiyskiy finik, tamarind
Estonian	Tamarindipuu	Sanskrit	Tintiri, tintiddii
Farsi	Tamre hendi	Singhalese	Siyambula
Finnish	Tamarindi	Somalia	Hamar (som)
French	Tamarin	Spanish	Tamarindo
German	Tamarinde, Indische Dattel, Sauerdattel	Swahili	Ukwaju
Gujrati	Amli	Swedish	Tamarind
Hausa	Tsamiya	Tagalog	Sampalok
Hebrew	Tamar hindi	Tamil	Puli
Hindi	Imli	Tanzania	Ukwaju
Hungarian	Tamarindus gyumoles, Indiai datolya	Thai	Mak kham
Indonesian	Asam jawa, Asam kuning	Turkish	Demirhindi
Italian	Tamarindo	Vietnamese	Me (chua), Cay me
Japanese	Tamarindo	Virgin islands	Tanan
Kannada	Amla, Huli, Hunise mara	Wolof	Daharg, dakah, dakhar
Khmer	Ampil khui, Ampil tum	Zambia	Mushishi (B), Mwemba (N), Musika (T)
Laotian	Kok mak kham		

Source: Sarker,[15], Santosh *et al*.,[16], Millind,[5]

2. Methodology of the Review

A number of investigators have published a vast of research and review communication on tamarind plant. Most of these review studies were centered toward general context about the plant and its uses. Although, none of this work solely dealt with a particular parameter that could oblige a general attribute for other related potential properties. This work aimed at comprehensive report on phytochemical content and antioxidant potential of this plant. The property could function as inherent to many of all it properties reported in the literature ranging from biological/medicinal to some enviromental application.

The literature was gathered from various data database and platforms including NCBI, Google Scholar, Web of Science, Science Direct, Research Gate and Open Google searches. Search terms such as; 'tamarind', '*Tamarindus indica'*, 'antioxidant and phenolic content of tamarind' and others queries were used in sourcing information from scholarly journals, reports, book, book series and conference papers from net. About one hundred and fifty (150) papers were sourced from online search and screened down to seventy six (76) based on year of publication (mostly 2010 to date) and topic relevance. An attempt was made to judge between various findings on phenolic content and antioxidants potentials of different part of this plant using comprehensive meta-analysis. But, difference in analytical tools and governing principles behind every antioxidant assay may not guide us to a reliable and representative interpretation. Therefore, reader may have to refer to the original articles for details about analytical methods and correct interpretation of the results based on theprevailing conditions.

3. Results

3. 1 Phytochemicals and Antioxidant Potentials of Tamarind

Wide number of biological activities of tamarind has been reported, most were attributed to its potential antioxidant properties. Phytochemical screening of virtually all parts of this plant revealed the presence of flavanoid, tannins, terpenoids and citric acids[Table 2] [17][18][19][20]. The biological role of tamarind associated with antioxidant potentials includes; anti-inflammatory, antimicrobial, anticancer, antidiabetic, antifungal, antinematodal, antiviral, moluscidal and cytotoxic[6][18][21][3][16]. The widely domestic and industrial use of tamarind pulp is likely attributed to the presence of phytonutrient that gives powerful dietary antioxidant and total phenolic content[22]. Tamarind pulp are extensively reported as rich in phenolic content and antioxidant capacity[13] with distinguished sweet acidic taste which may be due to high content of tartaric acid[23][24]. Shridhar and Kumar report shows a strong positive connection between the total phenol content of tamarind pulp and antioxidant activity determined using DPPH, ABTS and FRAP methods[25][21][26]. Total phenolic content and antioxidant capacity of tamarind pulp determined using FRAP, ABTS and DPPH method was found to be promising when compare with plant known to have high antioxidant potentials[27]. Konan *et al*., reported this antioxidant capacity to follow the order: baobab > Roselle > tamarind > ginger > passion > lemon, respectively. In comparative attempt with mango, longan, jackfruit and avocado, tamarind pulp shows a greater antioxidant and phenolic content[28]. In another study, total phenolic and antioxidant activity of tamarind pulp was also found to be highest when compared to star fruit, Indian gooseberry, ambarella and satkara[29]. Phenolic content and hydrolysable polyphenols such as catechin, epicatechin, taxifolin, apigenin, Eriodictiol and luteolin may be responsible for high antioxidant activity reported by Sayago-Ayerdi *et al*.,[30], Gueye *et al*.,[31] using FRAP, DPPH and ABTS methods. Sairah *et al*.,[23] reported on the presence of organic acid in tamarind leaves that could also play role in oxidation reduction reactions. Julio *et al*.,[11] and Aline *et al*.,[32] also reported on high content of flavanoids and phenolic from tamarind leaves and seed[4] using thin layer chromatography and supercritical extraction method. Aline further compare antioxidant potentials of tamarind using ABT, DPPH and FRAP method with fourteen other plants and found to be reasonably impressive. Mulyani *et al*.,[33] asserted that antioxidant effects of tamarind leaves is due to the presence of ascorbic acid, phenolics[16][34] and flavanoid content[35]. Other reports by Murugan *et al*.,[36] revealed high antioxidant capacity of a stored young tamarind leaves powder. Antioxidant outcome of tamarind leaves can be complemented through synergistic interactions with other plants[33][37]. Strong antioxidant effect of tamarind leaves can be better explained in terms of this interaction between ascorbic acid, phenolics and vast number of flavanoids[38]. The leaves were also shown to have a proven hepatoprotective activity associated with the presence of poly-hydroxylated compounds, with many of them flavonolic in nature[17]. Narasimhacharya *et al*., demonstrated the ability of tamarind leaves, seed and pericarp extract to have high antioxidant capacity using ABTS and DPPH method, and its attributed to its high phenolic content[39]. Warangkana further relate these effect to inhibition of cancer cell growth observed in their study. Kannen *et al*., revealed an *in vivo* potentials of tamarind pulp against lipid peroxidation and increased the activity of endogenous antioxidant enzymes[14]. Atawodi and Mubarak further demonstrate an in-vivo hepato- and nephro-protective effect of leave, stem bark, seed, fruit pulp, fruit bark and root of Tamarind plant[40]. Vyas *et al*.,[41] revealed high antioxidant potential of tamarind seed coat using DPPH method. Uma and Sarkar also reported the effect of temperature and technique of extraction to be significant on antioxidant capacity and phenolic content of tamarind seed[42]. Nushrat and Nazrul Islam also reported on effect of temperature and two extraction solvent on phenolic content, ascorbic acid and antioxidant capacity of tamarind seed extract[43]. Finally, many studies reveal a positive linear relationship between antioxidant activity and total phenolic content of tamarind extracts.

Table 2. Antioxidant Allied Phytoconstituents from Different Part of Tamarind.

Phytoconstituents	**Parts Reported**	**Reference**
Catechin	Tamarind pulp	[30][21][44][16]
Epicatechin	Tamarind pulp, seed, pericarp	[30][45][21][44][46][16]
Taxifolin	Tamarind pulp	[30][16]
Eriodictyol	Tamarind pulp, pericarp	[30][44][16]
Apigenin	Tamarind pulp	[30][44][16]
Luteolin	Tamarind pulp	[30]
Procyanidin B2, dimer, trimer	Tamarind leaves, pulp, pericarp	[21][44][16]
Procyanidin B2, tetramer, hexamer, pentamer	Tamarind seeds	[44]
Taxifolin	Tamarind pericarp	[44]
Naringenin	Tamarind pericarp	[44]
Tartaric acid	Tamarind leaves, pulp	[23][24][26][18][21][3][19][36][46][47][16]
Oxalic acid	Tamarind leaves	[23]
Malic acid	Tamarind leaves, pulp	[23][26][18][3][19][36][16]
Citric acid	Tamarind leaves, pulp	[23][17][26][3][44][19][47][16]
succinic acid	Tamarind pulp	[3][19][16]

Phytoconstituents	Parts Reported	Reference
Acetic acid	Tamarind roots, stems, pulp, and leaves	[19][16]
Formic acid	Tamarind roots, stems, pulp, and leaves	[19][16]
vitamin C	Tamarind leaves, pulp	[6][21][33][3][48][44][47][43]
α-carotene	Tamarind leaves	[6]
2-hydroxy-3', 4'-dihydroxyacetophenone	Tamarind seed coat	[45][21][35]
Methyl 3,4-dihydroxybenzoate	Tamarind seed coat	[45][21][35]
3,4-dihydroxyphenyl acetate	Tamarind seed coat	[45][21]
Tannins	Tamarind pulp	[17][21][3]
Terpenoids	Tamarind pulp	[17][26]
Lupanone	Tamarind leaves	[33][49]
Lupeol	Tamarind leaves	[33][3][49][46][47][16]
Palmitic acid	Tamarind seed	[3][47]
Oleic acid	Tamarind leaves	[3][47]
Ferulic acid	Tamarind leaves	[47]
Caffeic acid	Tamarind leaves	[47]
Linoleic acid	Tamarind leaves	[3]
Geraniol	Tamarind leaves	[3]
Limonene	Tamarind leaves	[3]
Pipecolic acid	Tamarind leaves	[3]
Orientin	Tamarind leaves	[3][47]
Isoorientin	Tamarind leaves	[3][47]
Vitexin	Tamarind leaves	[3][47]
Isovitexin	Tamarind leaves	[3][47]
Naringenin	Tamarind leaves	[16]
Pipecolic acid	Tamarind leaves	[3]
Nicotinic acid	Tamarind leaves	[3]
Safrole	Not specified	[44]
Cinnamic acid	Not specified	[44]
Pyrazine	Not specified	[44]

3.2 Environmental Application of Tamarind

Tamarind fruit has a considerable industrial importance but largely under-utilized in Nigeria and many other part of the world [Table 3] [7]. Tamarind seed powder has been used locally as natural bio coagulants in water to reduce turbidity and other parameters as an alternative to costly and side effects attributed chemicals[50]. Hefni *et al*.,[51] reported tamarind seed powder to be effective bio coagulant in gold mine waste water for removal of mercury. This ability might be due to its high protein content which act as natural polyelectrolyte whose utility is similar to synthetic coagulant[51][12][52]. Although, less effective, natural coagulant are reported to be cheap, environmentally friendlier and produce much smaller sludge volume[51]. Giwa *et al*.,[53] also reported on the use of tamarind seed powder as effective bio-coagulant in treatment of detergent waste water with significant reduction in turbidity and chemical oxygen demand. Seed polysaccharide was also reported to be use as a carrier in drug delivery[54]. Tamarind leaves contained citric, malic, tartaric and oxalic acids which are considered economical, environment-friendly, and reliable in sustainable weed-management because of their allelopathic potentials[23]. Tamarind juice has also been reported to play role as natural biocatalyst in some industrial chemical transformation[55]. The interest on the use fruit juice in organic synthesis is mainly due to their acidic properties, enzymatic activity and benign environmental character[55]. Tamarind seed polysaccharide (TSP) has shown to be useful in pharmaceutical, textile and food industries as a mucoadhesive polymer[56]. Because of their great properties such as biocompatibility, biodegradability and non-toxicity, they ought to be used in control drug release[56]. Tamarind pod shell otherwise discarded as tamarind waste can be used in waste water treatment for sorption of heavy metals. Ahalya *et al*.,[57] reported on excellent hexavalent chromium sorption capacity of tamarind pod shell. Tamarind bark powder was also reported to be effective in biosorption of mercury (II) from effluent stream[58]. Activated charcoal prepared from tamarind seed shows excellent ability to adsorb iron (III) from waste water[59]. Sorption capacity of tamarind pulp at various conditions was also reported by Khalid and Kumar[60]. Tamarind kernel powder was found to be effective adsorbent for reducing the biochemical oxygen demand and total dissolved solid present in the dairy industry wastewater[61]. Sorption mechanism involving heavy metals was postulated and validated by many researchers using FTIR to involved interaction with major functional groups present in biosorbent material. Hence, level of phytoconstituents in plant materials could determine its applicability as effective biosorbent.

Table 3. Environmental Role of Different Part of Tamarind Plant.

Parts Reported	**Environmental Roles**	**Reference**
Tamarind leaves	Allelopathic chemicals	[23]
Tamarind pod shell	Biosorption of heavy metals	[57]
Tamarind seed powder	Bio-coagulant	[50][51][53]
Tamarind bark powder	Biosorption of mercury	[58]
Tamarind seed charcoal	Biosorption of iron	[59]
Tamarind seed	Drug carrier	[56][54]
Tamarind pulp	Biocatalyst	[55]
Tamarind kernel powder	Waste water treatment	[61]

4. Conclusion

Despite various extraction techniques and conditions, tamarind extract shows a very strong potency against oxidative radicals generated by a number of different antioxidant assay procedures. This property might strongly be associated to its numerous biological activities reported in the literature. Because of tamarind availability, this property can be harness into the field of environmental remediation to counter the high energy requirement, cost and production of toxic sludge associated with the use chemical reductant. Tamarind can be found fateful in bioreduction of toxic heavy metals as alternative to highly expensive and toxic chemical reductant.

Conflict of interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

References

[1] S. Kaundinnyayana, S. K. Mahadevaiahchandraiah and A. L. Udupa, "Evaluation of Diuretic Activity of Aqueous Extract of Ripe Fruit Pulp of *Tamarindus indica* L. in Rats," *MJSBH*, vol. 14, no. 2, pp. 22–27, 2015.

[2] T. Ranaivoson, K. Brinkmann, B. Rakouth and A. Buerkert, "Distribution, Biomass and Local Importance of Tamarind Trees in South-Western Madagascar, "*Global Ecology and Conservation*, vol. 4, no. 2015, pp. 14–25, 2015.

[3] S. P. Zohrameena, S. Mujahid, M. Bagga, P. Khalid, M. Noorul and H. Nesar, "Medicinal Uses & Pharmacological Activity of *Tamarindus indica*," *World Journal of Pharmaceutical Sciences*, vol. 5, no. 2, pp. 121–133, 2017.

[4] P. Maria, C. Lima, H. Hense, C. Dariva, E. Franceschi, and G. Ângela, "Obtaining Antioxidant Compounds from Seed of *Tamarindus indica* , Sweet Variety," in *III Iberoamerican Conference on Supercritical Fluids Cartagena de Indias*, 2013, no. October, pp. 1–7.

[5] D. Isha and P. Milind, "Imlii: A Craze Lovely," *International research journal of pharmacy*, vol. 3, no. 8, pp. 110–115, 2012.

[6] E. DeCaluwé and P. VanDamme and K. Halamov, "*Tamarindus indica* L .-A Review of Traditional Uses, Phytochemistry and Pharmacology," *afrika focus*, vol. 23, no. 1, pp. 53–83, 2010.

[7] A. A. Adeola and O. C. Aworh, "Sugar and Dietary Fibre Components of Tamarind (*Tamarindus indica* L.) Fruits from Nigeria," *Nigerian Food Journal*, vol. 28, no. 2, pp. 32–40, 2010.

[8] E. Ebifa-othieno, A. Mugisha, P. Nyeko, and J. D. Kabasa, "Knowledge , Attitudes and Practices in Tamarind (*Tamarindus indica* L.) Use and Conservation in Eastern Uganda," *Journal of Ethnobiology and Ethnomedicine*, vol. 13, no. 5, pp. 1–13. DOI 10.1186/s13002–016–0133–8, 2017.

[9] R. M. Havinga, A. Hartl, J. Putscher, S. Prehsler, C. Buchmann and C. R. Vogl, "*Tamarindus indica* L . (Fabaceae): Patterns of Use in Traditional African Medicine," *Journal of Ethnopharmacology*, vol. 127, no. 2010, pp. 573–588, 2010.

[10] J. Cesar, E. Arranz, and R. Pérez-rosés, "Effect of *Tamarindus indica* L . Leaves Fluid Extract on Human Blood Cells," *Natural Product Research*, p. : http://dx.doi.org/10.1080/14786419.2014.911296, 2014.

[11] J. Cesar, E. Arranz, R. Pérez-rosés, and H. J. Morris, "Role of Polyphenols in the Antimicrobial Activity of Ethanol *Tamarindus indica* L. Leaves Fluid Extract.," *Bol Latinoam Caribe Plant Med Aromat*, vol. 12, no. 5, pp. 516–522, 2013.
[12] T. G. Kazi, K. Usmanghani, A. Kabir, and T. H. Sheerazi, "Chemical Constituents of *Tamarindus indica* L . Medicinal Plant in Sindh," *Pak. J. Bot*, vol. 40, no. 6, pp. 2553–2559, 2008.
[13] S. M. Barbalho, S. Cristina, C. Trevisan, A. Pereira, P. Menezes, É. Guiguer, M. Oshiiwa, V. Sellis, A. Maria, R. Fiorini, and S. M. Barbalho, "Metabolic Profile and Atherogenic Indices of Rats Treated with *Tamarindus indica* and Menthapiperita Juice.," *International Journal of Phytomedicine*, vol. 9, no. 2017, pp. 151–156, 2017.
[14] F. Martinello, V. Kannen, J. J. Franco, B. Gasparotto, J. Y. Sakita, A. Sugohara, S. B. Garcia,and S. A. Uyemura, "Chemopreventive Effects of *Tamarindus indica* Fruit Extract against Colon Carcinogenesis Depends on the Dietary Cholesterol ...," *Food and Chemical Toxicology*, vol. 107, no. 2017, pp. 261–269, 2017.
[15] P. K. Sarker, "Monograph on Tentul (*Tamarindus indica* L.)," 2004, no. May, p. DOI: 10.13140/RG.2.2.25072.46082.
[16] S. S. Bhadoriya, A. Ganeshpurkar, J. Narwaria, G. Rai and A. P. Jain, "*Tamarindus indica* : Extent of Explored Potential," *Pharmacognosy Reviews*, vol. 5, no. 9, pp. 73–81, 2011.
[17] C. Gupta, S. Prakash, and D. Gupta, "Studies on the Antimicrobial Activity of Tamarind (*Tamarindus indica*) and its Potential as Food Bio-preservative," *International Food Research Journal*, vol. 21, no. 2437–2441, 2014.
[18] M. G. Abubakar, A. N. Ukwuani and R. A. Shehu, "Phytochemical Screening and Antibacterial Activity of *Tamarindus Indica* Pulp Extract," *Asian Journal of Biochemistry*, vol. 3, no. 2, pp. 134–138, 2008.
[19] R. A. Mahmudah, I. K. Adnyana, and N. Kurnia, "Anti-asthma Activity of Tamarind Pulp Extract (*Tamarindus Indica* L .)," *International Journal of Current Pharmaceutical Research*, vol. 9, no. 3, pp. 3–6, 2017.
[20] P. A. Sumayya, M. Murugan, S. T. Gopukumar, and P. K. Praseetha, "Estimation of Phytochemical, Antimicrobial and Molecular Comparison of Fruit Extracts of Garcinia ...," *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, vol. 7, no. 1, p. 1256, 2016.
[21] P. Kuru, "*Tamarindus indica* and its Health Related Effects," *Asian Pacific Journal of Tropical Biomedicine*, vol. 4, no. 9, pp. 676–681, 2014.
[22] S. Altuhami, B. Taha, A. Elazeem, A. Mohamed, and A. E. Osman, "The value of Tamarind (*Tamarindus indica* L.) Pulp and its Potential Use in Vinegar Production," *Nova Journal of Medical and Biological Sciences*, vol. 5, no. 3, pp. 1–8, 2016.
[23] S. Syed, Z. I. Ahmed, M. I. Al-Haq, A. Mohammad and Y. Fujii, "The Possible Role of Organic Acids as Allelochemicals in *Tamarindus indica* L . Leaves," *Acta Agriculturae Scandinavica*, vol. 64, no. 6, pp. 511–517, 2014.
[24] E. M. Abdallah, "*In vitro* Antibacterial Activities of the Crude Methanol Extract of *Tamarindus indica* L Fruit Pulp, A Native ...," *Indian Journal of Fundamental and Applied Life Sciences*, vol. 4, no. S3, pp. 74–78, 2014.
[25] S. N. Bhusari and P. Kumar, "Antioxidant Activities of Spray Dried Tamarind Pulp Powder as Affected by Carrier Type and their Addition Rate," in *International Conference on Food, Biological and Medical Sciences*, 2014, pp. 1–5.
[26] I. Iskandar and F. Setiawan, "Six-Month Chronic Toxicity Study of Tamarind Pulp (*Tamarindus indica* L.) Water Extract," *Scientia Pharmaceutica*, vol. 85, no. 10, p. doi:10.3390/scipharm85010010, 2017.
[27] A. G. Konan, Y. Konan and M. W. Kone, "Polyphenols Content and Antioxidant Capacity of Traditional Juices Consumed in Côte d ' Ivoire," *Journal of Applied Biosciences*, vol. 87, pp. 8015–8021, 2015.
[28] Y. Yean-Soon and P. J. Barlow "Antioxidant Activity and Phenolic Content of Selected Fruit Seeds," *Food Chem*, vol. 88, pp. 411–417, 2004.
[29] M. A. Rahman, M.M. Khan, F.E. Das and R. Hossain, "Antioxidant Activity and Total Phenolic Content of Some Indigenous Fruits of Bangladesh," *International Food Research Journal*, vol. 23, no. 6, pp. 2399–2404, 2016.
[30] M. E. Páez-Peñuñuri, G. Mercado-Mercado, F. J. Blancas-Benitez, R. B. Villegas-González and S. G. Sáyago-Ayerd, "Compuestos Bioactivos Y Propiedades Saludables Del Tamarindo (*Tamarindus indica* L.)," *Biotecnia*, vol. XVIII, no. 1, pp. 10–21, 2016.
[31] A. I. Mbaye, P. M. Gueye and A. D. Fall *et al*., "Antioxidative Activity of *Tamarindus indica* L . Extract and Chemical Fractions," *African Journal of Biochemistry Research*, vol. 11, no. 2, pp. 6–11, 2017.
[32] A. Lamien-Meda, C. E. Lamien, M.Y. C. Moussa, N. T. M. Roland, M. Kiendrebeogo and B. Zeba, "Polyphenol Content and Antioxidant Activity of Fourteen Wild Edible Fruits from Burkina Faso," *Molecules*, vol. 13, pp. 581–594, 2008.

[33] S. Mulyani, B. Admadi and H. N. S. Antara, "An Assessment of Antioxidant Characteristics from Different Ratios of Turmeric and Tamarind (*Curcuma domestica* Val . - *Tamarindus indica* L .) Leaves Extracts .," *Australian Journal of Basic and Applied Sciences*, vol. 10, no. 14, pp. 347–353, 2016.
[35] J. M. Q. Arranz, R. P-Roses, I.L. Jimenez, J.R Amado, H. A-Coello, J. H. C-Lay and G. S. Gonzalez, "Chemical Constituents of *Tamarindus Indica* L. Leaves.," *Revista cubama de Quimica*, vol. XXII, no. 3, 2010.
[36] M. Yogeswari, B. S. Baharin and G. Palanivel, "Effect of Room Temperature Storage on the Physicochemical and Antioxidant Properties of Oven Dried Young Tamarind Leaves (*Tamarindus Indica*)," *Indian Journal of Science and Technology*, vol. 9, no. 48, p. DOI: 10.17485/ijst/2016/v9i48/91997, 2016.
[37] M. L. Noguer and B. C. Ana "Synergism Effect between Phenolic Metabolites and Endogenous Antioxidants in Terms of Antioxidant Activity," *Advances in Chemical Engineering and Science*, vol. 4, pp. 258–265. Published Online http://dx.doi.org/10.423, 2014.
[38] M. S. Brewer, "Natural Antioxidants: Sources, Compounds, Mechanisms of Action and Potential Applications," *Comprehensive Reviews in Food Science and Food Safety*, vol. 10, 2011.
[39] S. C. Warangkana, T. Utaipan and N. Somchit, "Antioxidant and Antiproliferative Activities of Non-Edible Parts of Selected Tropical Fruits," *Sains Malaysian*, vol. 43, no. 5, pp. 689–696, 2011.
[40] L. L. Mubarak and S. E. Atawodi, "Hepatoprotective and Nephroprotective Effects of Methanolic Extract of Different Parts of Tamarindus Indica Linn in Rats Following Acute and Chronic Carbon Tetrachloride intoxication.," *Annual Research & Review in Biology*, vol. 5, no. 2, pp. 109–123, 2015.
[41] N. Vyas, N. P. Gavatia, B. Gupta, "Antioxidant Potential of *Tamarindus indica* Seed Coat.," *Journal of Pharmacy Research*, vol. 2, pp. 1705–6, 2009.
[42] A. Sarkar and U. Ghosh, "Effect of Extraction Temperature and Technique on Phenolic Compounds and Antioxidant Activity of...," *Research Journal of Recent Sciences*, vol. 6, no. 2, pp. 10–15, 2017.
[43] N. Yeasmen and N. Islam, "Ethanol as a Solvent and Hot Extraction Technique Preserved the Antioxidant Properties of Tamarind (*Tamarindus indica*) Seed," *J. Adv. Vet. Anim. Res*, vol. 2, no. 3, pp. 332–337, 2015.
[44] R. K. Maheshwari, B. L. Jat, S. Khan and M. Mavai, "To Demystify Savory *Tamarindus indica* Linn. for Healthcare," *International Journal of Pharmacy and NaturalMedicines*, vol. 2, no. 2, pp. 173–179, 2014.
[45] T. Tsuda, T. Watanabe, M. Ohshima, K. Yamamoto, A. Kawakishi and S. Osawa, "Antioxidative Components Isolated from the Seed of Tamarind (*Tamarindus indica* L.).," *Journal of Agricultural and Food Chemistry*, vol. 42, pp. 2671–2674, 2004.
[46] F. Olaifa and B. Emikpe, "Phytochemical Components and Antibacterial Activity of *Tamarindus indica* Linn . Extracts against Some ... ," *Biotechnology Journal International*, vol. 17, no. 2, pp. 1–7, 2017.
[47] J. Rafael, R. Amado, J. Cesar, E. Arranz, J. F. Infante, J. Rafael, R. Amado, A. L. Prada, J. Cesar, E. Arranz, R. P. Rosés, H. M. Quevedo, H. Keita, E. P. Zapata, C. P. Fernandes, J. Carlos and T. Carvalho, "Antioxidant and Hepatoprotective Activity of a New Tablets Formulation from *Tamarindus indica* L .," *Hindawi Publishing Corporation Evidence-Based Complementary and Alternative Medicine*, vol. 2016, p. http://dx.doi.org/10.1155/2016/3918219, 2016.
[48] I. Khan, A. U. Rehman, S. H. Khan, I. M. Qazi, A. khan, F. N. Shah and T. U. Rehman, "Development and Quality Evaluation of Tamarind Plum Blended Squash During Storage," *Journal of Food Processing & Technology*, vol. 8, no. 3, p. doi: 10.4172/2157–7110.1000662, 2017.
[49] S. Iman, I. Azhar and M. M. Hasan, "Two Turpentine's Lupinone and Lupeol isolated and Identified from *Tamarindus indica* Linn.," *Pakistan journal of pharmaceutical science*, vol. 20, no. 20, pp. 125–127, 2007.
[50] S. S. C. Mohan, S. Shasi and P. S. Shakthivel, "Study of Surface Water Quality and its Treatment Using Bio-coagulants," *International Journal of Research in Engineering and Technology*, vol. 5, no. 11, pp. 15–17, 2016.
[51] R. H. Effendi and S. H. Hefni, "Tamarindus indica Seed as Natural Coagulant for Traditional Gold Mining Wastewater Treatment," *World Applied Sciences Journal*, vol. 35, no. 3, pp. 330–333, 2017.
[52] J. Ly, O. Sjofjan, and I. H. Djunaidi, "Enriching nutritive value of tamarind seeds by Saccharomyces cerevisiae fermentation," *J Biochem Tech*, vol. 7, no. 2, pp. 1107–1111, 2017.
[53] A. G. Ronke, R. Ayangunna and S. O. Giwa, "Coagulation-Flocculation Treatment of Industrial Wastewater Using Tamarind Seed Powder.," *International Journal of ChemTech Research*, vol. 9, no. 05, pp. 771–780, 2016.
[54] S. B. Yarragudi, R. Richter, H. Lee, G. F. Walker, A. N. Clarkson, H. Kumar, and S. B. Rizwan, "Formulation of Olfactory-targeted Microparticles with Tamarind Seed Polysaccharide to Improve Nose-to-brain Transport of Drugs," *Carbohydrate Polymers*, vol. 163, no. 2017, pp. 216–226, 2017.
[55] R. Pal, "Fruit Juice : A Natural , Green and Biocatalyst System in Organic Synthesis Fruit Juice : A

Natural , Green and Biocatalyst System in Organic Synthesis," *Open Journal of Organic Chemistry*, vol. 1, no. 4, pp. 47–56, 2013.

[56] P. Saengtongdee, P. Kaemchantuek and K. Chawananorasest, "Extraction and Characterization of Tamarind (*Tamarind indica* L.) Seed Polysaccharides (TSP) from Three Difference Sources," *Molecules Article*, vol. 21, no. 775, pp. 1–9 doi:10.3390/molecules21060775, 2016.

[57] N. Ahalya, R. D. Kanamadi, and T. V Ramachandra, "Biosorption of chromium (VI) by *Tamarindus indica* Pod Shells," *Journal of Environmental Science Research International*, vol. 1, no. 2, pp. 77–81, 2008.

[58] K. Kumaraguru, D. Vinoth, R. S. Kumar, S. R. Lal, and M. Rengasamy, "Mercury (II) Ions Removal by Adsorption," *Elixir Renewable Energy 102*, vol. 102, no. 2017, pp. 44236–442338, 2017.

[59] S. Mopoung, P. Moonsri, W. Palas, and S. Khumpai, "Characterization and Properties of Activated Carbon Prepared from Tamarind Seeds by KOH Activation for Fe (III) Adsorption from Aqueous Solution," *Hindawi Publishing Corporation The Scientific World Journal*, vol. 2015, p. 9 pages http://dx.doi.org/10.1155/2015/415961, 2015.

[60] K. Muzaffar and P. Kumar, "Moisture Sorption Isotherms and Storage Study of Spray Dried Tamarind Pulp Powder," *Powder Technology*, vol. 291, no. 2016, pp. 322–327, 2016.

[61] D. Sivakumar, D. Shankar, K. Poovarasi, and C. Das, "Treatment of Dairy Industry Wastewater – A Novel Adsorbent Tamarind Kernel Powder Treatment of Dairy Industry Wastewater," *International Journal of Advanced Research in Basic Engineering Sciences and Technology (IJARBEST)*, vol. 3, no. 35, pp. 6–11, 2017.