Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/23998
DOI URL: http://dx.doi.org/10.21474/IJAR01/23998

ISSN (O): 2320-5407
ISSN (P): 3107-4928

RESEARCH ARTICLE

UNVEILING ANTIOXIDANT ACTIVITY OF NATIVE FRUITS AND VEGETABLES: AN EXPERIMENTAL APPROACH

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Manuscript Info

Manuscript History
Received: 12 June 2026
Final Accepted: 14 July 2026
Published: August 2026

Key words:-
Native fruits; Native vegetables; Antioxidant activity; DPPH; FRAP; Free-radical scavenging; Total phenolic content; Ficus racemosa; Phyllanthus emblica; Terminalia chebula; Functional foods; Nutraceuticals.

Abstract

The present study evaluated the antioxidant potential of selected native fruits,vegetables,and medicinal plant resources through a comprehensiv e in-vitro experimental approach. Ten plant samples, namely Musa paradisiaca flower and fruit, Solanum torvum, Syzygiumcumini, Pithecellobium dulce, Ficus racemosa, Phyllanthus emblica, Terminalia chebula, Vitis vinifera, and Ziziphus jujuba, were investigated for their free-radical scavenging and reducing capacities. Shade-dried plant materials were extracted and subjected to DPPH radical scavenging, ferric reducing antioxidant power (FRAP), hydrogen peroxide scavenging, superoxide radical scavenging, and nitric oxide scavenging assays. Total phenolic content (TPC) was also determined using the Folin–Ciocalteu method. Considerable variation in antioxidant activity was observed among the investigated samples. In the DPPH assay, Ziziphus jujuba exhibited the highest inhibition (79.75%), followed by Ficus racemosa (78.19%), Pithecellobium dulce (75.70%), and Syzygiumcumini (75.08%). Musa paradisiaca flower showed the highest FRAP activity (75.47%), whereas Ficus racemosa demonstrated the strongest superoxide scavenging activity (79.50%). Hydrogen peroxide scavenging was highest in Musa paradisiaca flower (65.06%), while Phyllanthus emblica exhibited the maximum nitric oxide scavenging activity (60.77%). The highest total phenolic content was recorded in Terminalia chebula (725 µg GAE/ml), followed by Solanum torvum (676 µg GAE/ml) and Vitis vinifera (650 µg GAE/ml).

Overall, the findings demonstrate substantial antioxidant potential among the selected native plant resources, with phenolic and flavonoid constituents likely contributing to the observed activities. The study highlights their potential value as natural antioxidant sources for functional foods, nutraceuticals, and pharmaceutical applications and supports further investigation of their bioactive compounds.

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Introduction:-

Antioxidants are molecules that inhibit oxidation by neutralizing free radicals, which are unstable atoms or molecules containing unpaired electrons capable of damaging essential cellular components, including lipids, proteins, carbohydrates, and DNA (Halliwell, 1995). Under normal physiological conditions, reactive oxygen species (ROS) and reactive nitrogen species (RNS) are generated as a consequence of cellular metabolism and participate in several important biological processes. However, excessive production of these reactive species or inadequate antioxidant defense can result in oxidative stress. Oxidative stress is associated with molecular and cellular damage and has been implicated in the development and progression of several chronic disorders, including cancer, diabetes, neurodegenerative diseases, and cardiovascular diseases (Pham-Huy et al., 2008).

The antioxidant defense system of the human body consists broadly of enzymatic and non-enzymatic components that work together to maintain redox homeostasis. Enzymatic antioxidants constitute an important endogenous defense mechanism against free-radical-mediated damage. Major antioxidant enzymes include superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). These enzymes act sequentially or cooperatively to convert reactive oxygen species into relatively less harmful products, thereby limiting oxidative damage to cellular components (Birben et al., 2012). The coordinated action of these endogenous enzymes is essential for maintaining physiological antioxidant protection and controlling the accumulation of reactive species.

In addition to endogenous enzymatic defenses, non-enzymatic antioxidants obtained through the diet make an important contribution to the antioxidant network. These include vitamin C (ascorbic acid), vitamin E (tocopherols), carotenoids, polyphenols, and glutathione, together with other vitamins, minerals, and phytochemicals (Prior & Cao, 2000). Dietary antioxidants are particularly important because plant-based foods provide a chemically diverse combination of antioxidant constituents rather than a single compound. Their combined activities may contribute to the maintenance of cellular redox balance and protection against oxidative damage. Fruits, vegetables, tea, coffee, spices, and medicinal plants are recognized as important natural sources of polyphenols and flavonoids with antioxidant properties (Pisoschi& Pop, 2015).

Natural antioxidants have received increasing attention as alternatives to synthetic antioxidant compounds. Synthetic antioxidants such as butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) have been widely used in the food industry to retard lipid peroxidation and improve product stability; however, concerns regarding their safety and long-term use have encouraged interest in naturally derived alternatives (Pokorný, 2007). Plant-derived antioxidants offer considerable chemical diversity and may provide additional nutritional and functional benefits. Consequently, fruits, vegetables, spices, and medicinal plants are increasingly being investigated as sources of natural antioxidant compounds for dietary, functional-food, and nutraceutical applications.

The protective action of antioxidants occurs through several complementary mechanisms. One of the major mechanisms is free-radical scavenging, in which an antioxidant donates an electron or hydrogen atom to a reactive radical and converts it into a more stable molecule. Another important mechanism is metal chelation, whereby antioxidant compounds bind transition metals such as Fe^{2+} and Cu^{2+} and thereby reduce metal-catalyzed reactions involved in reactive oxygen species generation. Antioxidants may also participate in the regeneration of other antioxidant molecules. For example, vitamin C can contribute to the regeneration of oxidized vitamin E, thereby supporting the overall antioxidant defense network (Sies, 1997). These complementary mechanisms demonstrate that antioxidant activity is a multifaceted property that cannot always be represented adequately by a single biochemical reaction.

The biological importance of antioxidants is closely associated with their potential role in protecting tissues from oxidative damage. Dietary polyphenols have been associated with protection against oxidative modification of low-density lipoprotein (LDL) cholesterol and may therefore contribute to cardiovascular health (Scalbert et al., 2005). Dietary antioxidants may also reduce oxidative damage to DNA and thereby contribute to mechanisms relevant to cancer prevention (Frei, 1994). Similarly, flavonoids and vitamins have been investigated for their ability to modulate oxidative stress associated with neurodegenerative disorders such as Alzheimer's and Parkinson's diseases (Joseph et al., 2009). Oxidative stress is also recognized as an important factor associated with atherosclerosis, diabetes, neurodegeneration, and cancer (Halliwell, 2007). Diets rich in fruits and vegetables provide diverse antioxidant compounds capable of scavenging reactive species, chelating metals, and supporting endogenous defense pathways. In particular, traditional South Asian diets contain a wide variety of native fruits, vegetables, herbs, and spices with considerable antioxidant potential, providing an important basis for exploring indigenous plant resources as dietary sources of bioactive compounds.

Assessment of antioxidant potential generally involves a combination of in-vitro assays because individual methods measure different aspects of antioxidant activity. Commonly used methods include DPPH and ABTS radical-scavenging assays, which primarily reflect electron- or hydrogen-donation capacity; the ferric reducing antioxidant power (FRAP) assay, which measures ferric-reducing ability (Benzie & Strain, 1996); and the oxygen radical absorbance capacity (ORAC) assay, which evaluates peroxyl radical-scavenging capacity and is relevant to chain-breaking antioxidant activity (Prior et al., 2005). Since these assays differ in their reaction mechanisms, reaction conditions, sensitivity, and susceptibility to food-matrix effects, results obtained using different methods may not be directly comparable. Therefore, the application of multiple complementary assays is recommended for a more robust interpretation of antioxidant potential (Apak et al., 2016).

Among native fruits, Phyllanthus emblica (amla or Indian gooseberry) is recognized as an important source of antioxidant compounds. It is particularly rich in ascorbic acid, gallic acid, ellagic acid, and hydrolyzable tannins, which contribute to its antioxidant activity in assays such as DPPH and FRAP (Benzie & Strain, 1996; Baliga & Dsouza, 2011). Studies and contemporary reviews have further reported strong antioxidant capacity and inhibition of lipid peroxidation in both in-vitro and in-vivo models (Kumar et al., 2022; Bashir et al., 2018). The phytochemical richness of amla makes it an important traditional food resource and a potential source of bioactive compounds for functional-food and nutraceutical applications.

Syzygiumcumini (jamun) represents another important native fruit with substantial antioxidant potential. Its pulp contains anthocyanins, including malvidin, petunidin, delphinidin, cyanidin, and peonidin, while its seeds contain high levels of ellagitannins and have been reported to exhibit greater ORAC and FRAP values than the pulp (Seeram et al., 2011). The antioxidant and hypoglycemic properties of jamun have been associated largely with its phenolic and anthocyanin constituents (Swami et al., 2012; Singh et al., 2022). These characteristics support the importance of jamun as a traditional fruit with potential nutritional and functional significance.

Pithecellobium dulce (Manila tamarind) is a leguminous tree widely distributed in tropical and subtropical regions. Different plant parts, including leaves, bark, pulp, and seeds, contain polyphenols, flavonoids, tannins, and vitamin C, which contribute to its antioxidant potential. Methanolic and aqueous extracts of P. dulce have demonstrated antioxidant activity in DPPH, ABTS, FRAP, and nitric oxide-scavenging assays, indicating their ability to neutralize reactive species and reduce oxidative stress (Singh et al., 2015). In addition, fruit extracts have been investigated for chemopreventive and anticancer effects, which have been attributed in part to their phenolic and flavonoid content (Reddy et al., 2012).

Ficus racemosa (cluster fig) is a medicinal tree widely distributed throughout tropical Asia and has traditionally been used in Ayurveda for conditions including diabetes, dysentery, and inflammation. Its therapeutic properties have been associated with a diverse phytochemical profile and antioxidant activity. Methanolic bark and fruit extracts have demonstrated activity in DPPH, ABTS, superoxide, hydroxyl-radical, and nitric-oxide-scavenging assays (Das et al., 2014). Phytochemical investigations have identified phenolics, flavonoids, tannins, glycosides, and triterpenoids in F. racemosa extracts. These compounds may contribute to free-radical scavenging and inhibition of oxidative processes, supporting the potential of this species for herbal and nutraceutical applications (Nariya et al., 2011).

Ziziphus jujuba, commonly known as jujube or red date, is another medicinal and nutritional fruit tree with a long history of traditional use. Its fruits, seeds, and leaves contain flavonoids, phenolic acids, saponins, polysaccharides, and vitamin C. The polysaccharides have been associated with both immunomodulatory and antioxidant functions, including enhancement of endogenous antioxidant enzymes such as SOD, CAT, and GPx (Gao et al., 2013). Flavonoids and phenolic constituents contribute to radical-scavenging activity against DPPH, hydroxyl radicals, and superoxide anions, while fruit and seed extracts have also demonstrated reducing capacity and inhibition of lipid peroxidation (Li et al., 2005).

Vitis vinifera is a particularly important source of polyphenolic antioxidants, including flavonoids, resveratrol, tannins, anthocyanins, and phenolic acids. Resveratrol, a stilbene concentrated particularly in grape skins, has been associated with antioxidant and anti-inflammatory properties and with modulation of endogenous antioxidant enzymes such as SOD, CAT, and GPx (Shi et al., 2003). Grape seeds, skins, and pulp have all been investigated for their antioxidant effects, with grape-seed extracts being particularly rich in proanthocyanidins. These compounds exhibit radical-scavenging activity, inhibit lipid peroxidation, and may protect cellular components from oxidative damage (Bagchi et al., 2000).

Terminalia chebula, commonly known as Haritaki or Chebulic myrobalan, is extensively used in Ayurveda and Siddha medicine and is traditionally recognized for its broad therapeutic properties. Its antioxidant activity has been investigated using DPPH, ABTS, FRAP, and nitric-oxide-scavenging assays, with fruit extracts demonstrating substantial antioxidant capacity (Saleem et al., 2002). The fruits contain tannins, flavonoids, polyphenols, chebulinic acid, chebulagic acid, gallic acid, and ellagic acid, which collectively contribute to free-radical scavenging and inhibition of lipid peroxidation. Extracts have also been reported to enhance endogenous antioxidant defenses involving SOD, CAT, and GPx (Naik et al., 2004).

Native vegetables and traditionally consumed plant parts also represent valuable sources of antioxidants. Musa spp., particularly banana flower and raw banana, contain phenolic compounds, flavonoids, tannins, dietary fibre, resistant starch, and vitamin C. Banana-flower extracts have demonstrated activity in DPPH, ABTS, FRAP, and nitric-oxide-scavenging assays, together with effects on lipid peroxidation and endogenous antioxidant enzymes (Bala et al., 2010; Nirmala et al., 2011). Raw banana contains dietary fibre, resistant starch, phenolics, and vitamin C and has demonstrated free-radical-scavenging activity (Singh et al., 2016; Umesh et al., 2019). These characteristics support the potential application of banana flower and raw banana in functional foods and nutraceutical products.

Similarly, Solanum torvum, commonly known as Turkey berry or Sundakai, is traditionally used for various nutritional and medicinal purposes. Its antioxidant potential is associated with phenolic acids, flavonoids, alkaloids, tannins, terpenoids, and saponins, including compounds such as chlorogenic acid, caffeic acid, and quercetin (Palanisamy et al., 2011; Nisha et al., 2012). Extracts of S. torvum have demonstrated DPPH and ABTS radical-scavenging activity and have been associated with modulation of SOD, CAT, and GPx, together with inhibition of lipid peroxidation (Krishnan et al., 2014). These properties indicate its potential relevance as an antioxidant-rich traditional food resource and as an ingredient for functional-food development.

Importantly, antioxidant potential should not be interpreted solely according to whether a plant is classified as native or exotic. Native species are traditionally adapted to their regional agro-climatic conditions, whereas exotic species are introduced from other geographical regions. Both groups can contain substantial concentrations of antioxidant compounds, with differences influenced by genotype, environment, maturity, agricultural practices, and processing (Willett et al., 2006; Dumas et al., 2003). Underutilized native fruits may exhibit high phenolic content and antioxidant capacity, while exotic fruits such as blueberry, raspberry, blackberry, and kiwi are also recognized for their anthocyanin and flavonoid content (Uddin et al., 2020; Manach et al., 2004). Thus, antioxidant quality cannot be determined solely on the basis of geographical origin.

Genetic background and environmental conditions can substantially influence phytochemical accumulation. Different cultivars of crops such as tomato and grape may vary considerably in their antioxidant composition, while soil characteristics, sunlight exposure, agricultural practices, storage, and processing can further modify antioxidant levels (George et al., 2004; Dumas et al., 2003; Nicoli et al., 1999). In addition, combinations of different antioxidant compounds may result in additive or synergistic effects. Such interactions may involve radical scavenging, metal chelation, and regeneration of antioxidant molecules (Sies, 1997). Evidence from mixtures of polyphenols, vitamins, and fruit extracts supports the possibility of additive or synergistic antioxidant effects (Liu, 2004). Vitamin C, for example, can regenerate oxidized vitamin E and thereby enhance protection against lipid peroxidation (Jacob, 1995). Epidemiological evidence further suggests that diverse diets rich in fruits and vegetables may provide greater health benefits than reliance on isolated antioxidant supplements (Liu, 2003).

The biological effectiveness of these antioxidants is also strongly influenced by bioavailability, food-matrix interactions, and processing. Bioavailability refers to the fraction of an ingested antioxidant that is absorbed, metabolized, and made available at the site of physiological action (Manach et al., 2004). The bioavailability of vitamin C, polyphenols, and carotenoids depends on their chemical structure, interactions with digestive processes, and gut microbial metabolism. For example, tannins undergo microbial metabolism, curcumin has inherently low bioavailability that may be improved by piperine, and cooking can increase the bioavailability of certain carotenoids through disruption of plant cell structures (Naik et al., 2003; Shoba et al., 1998; Rao and Agarwal, 2000).

The food matrix can further modify antioxidant release and absorption. Fibre may retain polyphenols and reduce their immediate release, whereas dietary fat can enhance the absorption of lipophilic antioxidants such as β-carotene and lutein. Protein–polyphenol interactions may influence absorption, while organic acids can affect the stability and solubility of certain antioxidants (Palafox-Carlos et al., 2011; Saura-Calixto, 2011; Tang, 2010; Arts et al., 2001; Fernandez-Panchon et al., 2008). Processing may either improve or reduce antioxidant bioavailability. Cooking,

fermentation, juicing, and blending can facilitate the release of certain compounds, whereas excessive heating, drying, oxidation, or prolonged exposure to air can degrade sensitive constituents such as vitamin C, polyphenols, and carotenoids (Shi and Le Maguer, 2000; Hur et al., 2014; Lee and Kader, 2000; Nicoli et al., 1999; Rodriguez-Amaya, 1997).

Recent evidence further emphasizes that translating in-vitro antioxidant capacity into in-vivo benefit requires consideration of bioaccessibility, metabolism, and interactions with the gut microbiome. Phenolic compounds from fruits such as mango and pomegranate may undergo microbial metabolism that generates additional bioactive metabolites, while household processing can substantially influence phytochemical retention and availability (Hewlings& Kalman, 2017; Li et al., 2025; García-Muñoz & Vaillant, 2014; Sahin & Bilgin, 2013; Rickman et al., 2007). In parallel, the valorization of fruit peels and seeds from mango, pomegranate, and banana provides an opportunity to recover fibre- and polyphenol-rich ingredients with potential applications in functional foods (González-Mondragón et al., 2025; Álvarez-Parrilla et al., 2020).

Despite the substantial evidence supporting antioxidant-rich native produce, important research gaps remain. Antioxidant composition varies according to cultivar, maturity, agroecological conditions, and postharvest handling, while differences in assay methodology and reporting units can limit comparisons among studies. Although culinary consumption of these foods is generally considered appropriate, concentrated extracts may have pharmacological effects and potential interactions with medications. Therefore, future research should emphasize standardized food formats, validated biomarkers of oxidative stress, human bioavailability studies, and harmonized antioxidant-assay protocols, including consistent reporting of Trolox equivalents and fresh- versus dry-weight measurements (Álvarez-Parrilla et al., 2020; Bhat et al., 2022; Apak et al., 2016).

Taken together, native fruits and vegetables from South Asia represent diverse and potentially valuable sources of natural antioxidants with relevance to nutrition, functional-food development, and nutraceutical applications. Their antioxidant potential is determined not only by phytochemical composition but also by the interaction of multiple compounds, food-matrix characteristics, processing conditions, bioavailability, and dietary combinations. Therefore, a comprehensive evaluation that integrates antioxidant assays with phytochemical characterization, bioavailability, processing, safety, and human evidence is essential. This review consequently brings together the available information on selected native fruits, vegetables, and herbs, compares their antioxidant potential with selected exotic produce, examines synergistic interactions, and discusses the influence of food matrix and processing on antioxidant effectiveness. Greater utilization and scientific validation of these underexplored native resources may contribute to the development of nutrition-dense foods, value-added functional products, and more sustainable approaches to plant-resource utilization.

Materials and Methods:-

Sample Collection:-

Musa paradisiaca (vegetables and flower), Solanum torvum, Syzygiumcumini, Pithecellobium dulce, Ficus racemosa, Terminalia chebula, Zizipusmouritiana, Phyllanthusemblica, Vitis vinifera were collected from different place in Chennai.

Sample Preparation:-

The Collected fruits and vegetables were shade dry. After that they grained with fine or coarse powder and it stored in falcon tube or air tight container. For extraction (water) powder of (fruits, vegetables and flowers) samples were mixed with respective solvents. The extracts kept for overnight and filtered, by using whatman filter paper. After that the extract were poured the petriplate until they dry and scrap it for further use.

Determination of antioxidant Assay:-

DPPH Free Radical Scavenging Activity:-

DPPH – (2, 2’ diphenyl-1- picrylhydrazyl radical) assay. The samples were taken from different concentration(100µg, 200µg…..500µg) and added 1M of 3ml of DPPH Take different concentration of the sample and 1M of DPPH were added. Incubate for 30min under dark condition. Find absorbance at 517nm.The antioxidant activity of the samples was evaluated using the DPPH• radical scavenging assay. The mixtures were incubated in the dark for 30 min at room temperature, and absorbance was measured at 517 nm. Percentage inhibition was calculated relative to the control, and antioxidant potential was expressed as IC_{50} . Ascorbic acis is used as standard(Brand-Williams et al., 1995; Molyneux, 2004).

FRAP Ferric Reducing Antioxidant Power:-
Various concentration of extract were dissolved in respective solvents and added phosphate buffer (ph 6.8). 1% potassium ferrocynaide solution was added then incubate for 20min (pre heat 50˚C), after that 10% Trichloro acetic acid was added then centrifuge 3000 rpm were collected the supernatant. Take 2.5ml of supernatant with 2.5ml of distilled water (i.e equal amount). 0.5ml of ferric chloride was added mix thoroughly and take the OD value at 700nm by using spectrophotometry. Ascorbic acid as standard.(Benzie and Strain, 1996; Pulido et al., 2000).

Hydrogenper oxide scavenging Activity:-
The ability of the extract to scavenging hydrogen peroxide was determined according to the method of Rutch et.al (1989). 40mM of hydrogen peroxide in phosphate buffer (Ph 7.4). Extract 200 µg / ml in distilled water and added to Hydrogen peroxide solution (0.6 ml ,40mM). And take the absorbance at 230 nm. The blank is phosphate buffer without hydrogen peroxide.(Ruch et al., 1989; Akinmoladun et al., 2010).

Superoxide Radical Scavenging Activity:-
Reaction mixture contained 20mM of phosphate buffer (ph 7.4). 73µM of NADH, 50µM of NBT, 15µM of PMS and various concentration of samples and incubated for 5min. Absorbance at 562nm.(Huie and Padmaja, 1993; Halliwell and Gutteridge, 2015).

Nitric Oxide Radical Scavenging Activity:-
5mM of sodium nitroprusside in 0.1M of phosphate buffer (ph 7.4). Take different concentration of extract in phosphate buffer. The tubes were incubated at 25˚C for 2 hours. Added 1.5ml of Gresis reagent before that to remove the 1.5ml of reaction mixture at the end of 2 hours. By using spectrophotometer to take optical density at 546nm.(Marcocci et al., 1994; Garrat, 1964).

Determination of Phenol:-
Total phenolic content was determined using Folin Ciocaltu Reagent. By using gallic acid as standard. 0.5ml of extract was mixed with 0.5ml of Folin Ciocaltu reagent. Incubate for 5min at 22˚C. Then addition of 2ml of Na_2CO_3 and incubate at 22˚C for 90min. Absorbance was measured at 650nm.(Singleton & Rossi, 1965; Singleton et al., 1999).

Results and Discussion:-

Determinationofantioxidant Assay:-
(DPPH)2,2-Diphenyl-1-picrylhydrazylFree Radical Scavenging Activity:-
The DPPH radical scavenging assay is one of the most widely used and rapid methods to estimate antioxidant potential. It relies on both single electron transfer (SET) and hydrogen atom transfer (HAT) mechanisms for scavenging the stable DPPH free radical (Molyneux, 2004; Kedare & Singh, 2011). Its simplicity, cost-effectiveness, and reproducibility make it a popular choice for evaluating plant extracts (Brand-Williams et al., 1995; Prior et al., 2005).

In the present study, Table 1. and Figure 1 shows theDPPH radical scavenging activityof extracts of Ziziphus jujuba, Ficus racemosa, Pithecellobium dulce, and Syzygiumcumini demonstrated particularly strong radical scavenging activity (79.75%, 78.19%, 75.70%, and 75.08%, respectively). These high inhibition rates suggest robust antioxidant capabilities, likely due to high phenolic content—a factor well established in previous studies as a key contributor to DPPH scavenging activity (Rice-Evans et al., 1996; Cai et al., 2004).

Moderate activity was observed in Phyllanthus emblica, Terminalia chebula, and Vitis vinifera (74.46%, 71.96%, and 70.90%, respectively). These values still reflect appreciable antioxidant potential, comparable to other medicinal plants reported in literature (Kaur & Kapoor, 2001; Kumar et al., 2008). In contrast, Solanum torvum and Musa paradisiaca (Flower and Fruit) showed lower activity (69.63%, 68.53%, and 54.83%), possibly indicating lower concentrations of active phytochemicals or differing extract compositions.

Generally, inhibition above 70% indicates strong antioxidant activity within the DPPH assay (Blois, 1958; Brand-Williams et al., 1995). However, expressing antioxidant efficacy as IC_{50} would allow more direct comparisons across studies: lower IC_{50} values correspond to higher antioxidant strength (Sánchez-Moreno, 2002).
Despite its strengths, the DPPH assay has limitations: it may not fully reflect antioxidant behavior in biological systems because of steric hindrance, solvent effects (methanol/ethanol dependency), and lack of relevance to physiological free radicals (Apak et al., 2016; Prior et al., 2005).

In summary, the findings indicate that several of the tested plant extracts, especially Z. jujuba, F. racemosa, P. dulce, and S. cumini, hold significant DPPH radical scavenging activity, highlighting their potential as natural antioxidants.

FRAP (Ferric Reducing Antioxidant Power):-

The ferric reducing antioxidant power (FRAP) assay is widely used to evaluate the electron-donating capacity of plant extracts, which reflects their potential to neutralize free radicals. Table 2 and Figure 2 the present study, among the ten selected plant extracts, Musa paradisiaca flower exhibited the highest reducing ability (75.47%), while Syzygiumcumini showed the lowest (47.20%). The stronger FRAP activity of Musa paradisiaca flower and Vitis vinifera may be attributed to their rich content of polyphenols, flavonoids, and other phytoconstituents, which act as strong reducing agents (Benzie & Strain, 1996; Apak et al., 2008).

Previous reports also highlight that Musa paradisiaca is abundant in phenolic compounds such as gallic acid, catechin, and epicatechin, which significantly contribute to its antioxidant potential (Someya et al., 2002). Similarly, Vitis vinifera (grapes) are well known for their resveratrol and anthocyanin content, compounds that play a crucial role in scavenging free radicals and reducing oxidative stress (Poudel et al., 2008). The comparatively moderate antioxidant activity of Phyllanthus emblica and Terminalia chebula observed in this study aligns with earlier findings that reported their strong phenolic and tannin profiles, which impart moderate yet consistent antioxidant potential (Sultana et al., 2007).

The variation in FRAP activity among the tested plants could be linked to differences in their phytochemical composition. Plants with higher levels of polyphenols and flavonoids tend to show greater ferric ion reducing capacity. Overall, the present findings support the view that traditional medicinal plants serve as valuable sources of natural antioxidants, which may help in the prevention of oxidative stress-related disorders.

Hydrogen Peroxide Scavenging Assay:-

Hydrogen peroxide, although not a free radical itself, can generate highly reactive hydroxyl radicals inside the cell through the Fenton reaction, thereby causing lipid peroxidation, protein modification, and DNA damage (Halliwell & Gutteridge, 2015). The ability of plant extracts to scavenge hydrogen peroxide is therefore an important indicator of antioxidant activity. Figur e3 and Table 3 the present study, Musa paradisiaca (Flower) displayed the highest activity (65.06%), in line with earlier findings that reported significant antioxidant potential in banana flowers due to their phenolic and flavonoid contents (Singh et al., 2016).

Other samples such as Solanum torvum and Vitis vinifera also showed high scavenging activity, which is consistent with previous studies attributing their activity to high concentrations of phenolic acids and tannins (Kumar et al., 2019; Rajan et al., 2020). Moderate activity in Phyllanthus emblica and Syzygiumcumini supports earlier reports highlighting their ascorbic acid and ellagitannin content (Sharma & Kumar, 2017).

Ziziphus jujuba, with 49.43% inhibition, showed a comparatively lower scavenging potential, which could be linked to differences in phytochemical composition, as noted in earlier antioxidant profiling of Ziziphus species (Ahmed et al., 2014). The least activity in Pithecellobium dulce (42.61%) indicates that this species may have lower levels of hydrogen peroxide–neutralizing compounds compared to the others.

Overall, the findings highlight the efficiency of several native plants in mitigating oxidative stress through hydrogen peroxide scavenging, with banana flower, grape, and turkey berry showing the most promising activity.

Superoxide Scavenging Assay:-

At 200 µl concentration, all the selected plant extracts exhibited significant hydroxyl radical scavenging activity. Among the tested samples, Ficus racemosa showed the highest inhibition (79.50%), followed by Solanum torvum (73.00%) and Pithecellobium dulce (73.67%). Moderate inhibition was observed in Musa paradisiaca (Flower: 69.17%, Fruit: 67.50%), Syzygiumcumini (70.33%), Phyllanthus emblica (70.83%), and Ziziphus jujuba (69.50%). The lowest hydroxyl radical scavenging potential was recorded in Vitis vinifera (65.00%) and Terminalia chebula (66.33%). These findings indicate that phenolic-rich extracts such as Ficus racemosa and Pithecellobium dulce are more potent scavengers compared to other tested plants.

Hydroxyl radicals are highly reactive oxygen species capable of causing lipid peroxidation, DNA damage, and protein denaturation, contributing to oxidative stress and degenerative diseases. The ability of plant extracts to neutralize hydroxyl radicals is therefore an important measure of their antioxidant potential. In the present study,

table 4 and figure 4 all extracts showed considerable scavenging activity, with Ficus racemosa exhibiting the strongest effect (79.50%).

Previous studies have also reported the strong hydroxyl radical scavenging activity of Ficus racemosa bark extracts due to their high phenolic and flavonoid content (Kumar et al., 2014). Similarly, Pithecellobium dulce and Solanum torvum are known to contain alkaloids and tannins, which may contribute to their free radical quenching capacity (Anwar et al., 2020). The moderate activity observed in Musa paradisiaca and Phyllanthus emblica supports earlier reports highlighting their role in reducing oxidative damage through phenolic antioxidants (Singh & Rajini, 2008).

Nitric Oxidescavenging Assay:-

The nitric oxide scavenging assay demonstrated variable inhibitory effects among the tested plant extracts at 200 µl concentration. Table 5 and Figure 5 shows Phyllanthus emblica exhibited the highest inhibition (60.77%), followed by Musa paradisiaca (Fruit) (58.46%) and Musa paradisiaca (Flower) (56.15%). Moderate activities were observed in Syzygiumcumini (54.61%), Vitis vinifera (53.85%), and Ficus racemosa (53.07%). Lower inhibition percentages were recorded for Solanum torvum (52.31%), Ziziphus jujuba (50.00%), and Pithecellobium dulce (50.77%), while Terminalia chebula displayed the least activity (48.46%). These results indicate that Phyllanthus emblica possesses the most potent nitric oxide scavenging capacity among the studied samples, likely due to its high phenolic and ascorbic acid content.

Nitric oxide is a reactive free radical implicated in oxidative stress-related damage to cellular components, contributing to inflammation and chronic diseases. The inhibition of nitric oxide by plant extracts is an important indicator of their antioxidant potential. In this study, Phyllanthus emblica showed the strongest nitric oxide scavenging activity, which aligns with previous findings that report its rich content of vitamin C and polyphenols as major contributors to free radical neutralization (Singh et al., 2012). Similarly, Musa paradisiaca (Fruit and Flower) exhibited significant inhibitory effects, consistent with studies highlighting their bioactive phytochemicals, including flavonoids and phenolic acids, which contribute to antioxidant activity (Akinmoladun et al., 2010).

Moderate inhibition was observed for Syzygiumcumini and Ficus racemosa, supporting earlier reports that these plants contain anthocyanins, tannins, and other polyphenolics with free radical scavenging potential (Sharma et al., 2013). In contrast, Terminalia chebula showed relatively low nitric oxide inhibition in this study, despite being widely reported for its strong antioxidant properties, suggesting that activity may vary depending on solvent extraction, plant maturity, or assay conditions (Sabu &Kuttan, 2002).

Overall, the findings reinforce the role of natural phytochemicals in mitigating nitric oxide-mediated oxidative stress, with Phyllanthus emblica emerging as the most effective among the tested samples.

Determination of Phenol:-

Table 6 and Figure 6 shows the Total Phenol Content (TPC) of the ten extracts ranged from 435 to 725 µg GAE/ml. The highest phenolic load was observed in Terminalia chebula (725 µg GAE/ml), followed by Solanum torvum (676), Vitis vinifera (650), Syzygiumcumini (633), and Phyllanthus emblica (610). Moderate levels were recorded for Ficus racemosa (553) and Pithecellobium dulce (528), while Musa paradisiaca (flower) and Ziziphus jujuba showed comparable values (522 and 510, respectively). The lowest TPC was in Musa paradisiaca (fruit) (435 µg GAE/ml). Overall, the extracts with higher TPC broadly align with those showing stronger antioxidant performance in the free-radical assays, indicating a meaningful contribution of phenolics to the observed activities.

The Folin–Ciocalteu (F–C) method estimates total phenolics via electron transfer to the phosphomolybdic–phosphotungstic reagent, producing a blue chromophore typically read near 765 nm and expressed as gallic acid equivalents (GAE) (Singleton & Rossi, 1965; Singleton, Orthofer, &Lamuela-Raventós, 1999). In this study, Terminalia chebula exhibited the greatest phenolic content, consistent with its well-known richness in hydrolysable tannins, while Solanum torvum, Vitis vinifera, and Syzygiumcumini also showed high TPC, matching their literature-reported polyphenol profiles. The general concordance between higher TPC and stronger antioxidant activities in DPPH, superoxide, and hydrogen peroxide scavenging assays supports the widely reported positive association between phenolics and antioxidant capacity (Dudonnéet.al.,, 2009; Prior, Wu, & Schaich, 2005; Thaipong, et.al., 2006).

While the Folin–Ciocalteu method is robust and rapid, it is not entirely specific to phenolics; other reducing substances (such as ascorbate, sugars, and amino acids) may interfere (Everette, et.al., 2010). Therefore, coupling

TPC with multiple antioxidant assays—as performed here—provides a more reliable picture. Further studies employing chromatographic profiling (HPLC-DAD/LC-MS) can elucidate the contribution of specific phenolic subclasses such as flavonoids, anthocyanins, and tannins.

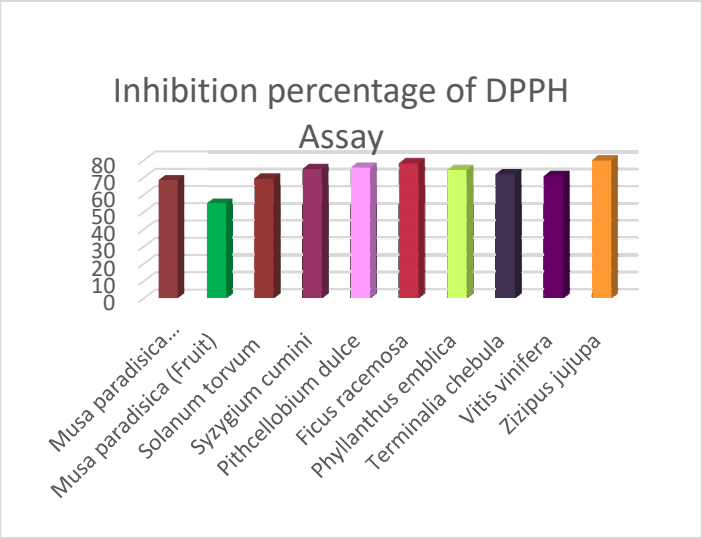

Figure 1(DPPH) 2,2-Diphenyl-1-picrylhydrazyl Free Radical Scavenging Activity of different samples.

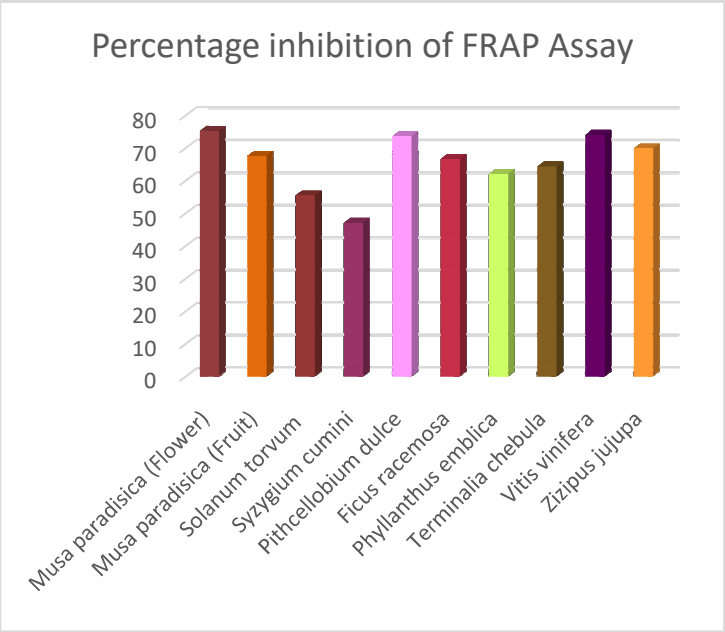

Figure 2 FRAP (Ferric Reducing Antioxidant Power) of different samples.

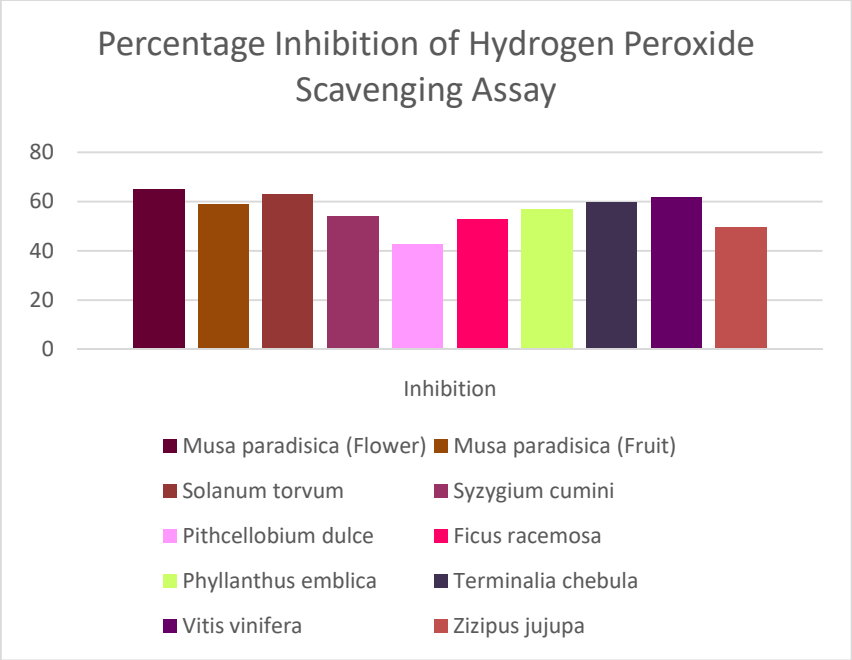

Figure 3Hydrogen Peroxide Scavenging Assay of different samples.

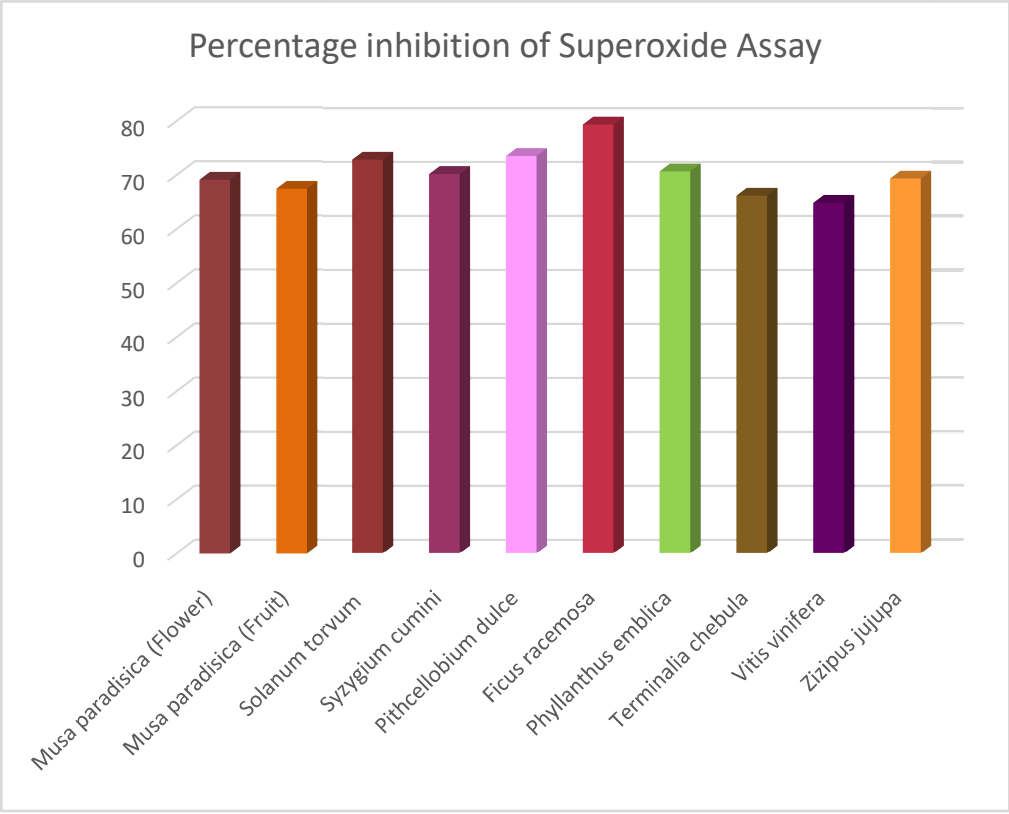

Figure 4 Superoxide Scavenging Assayof different samples.

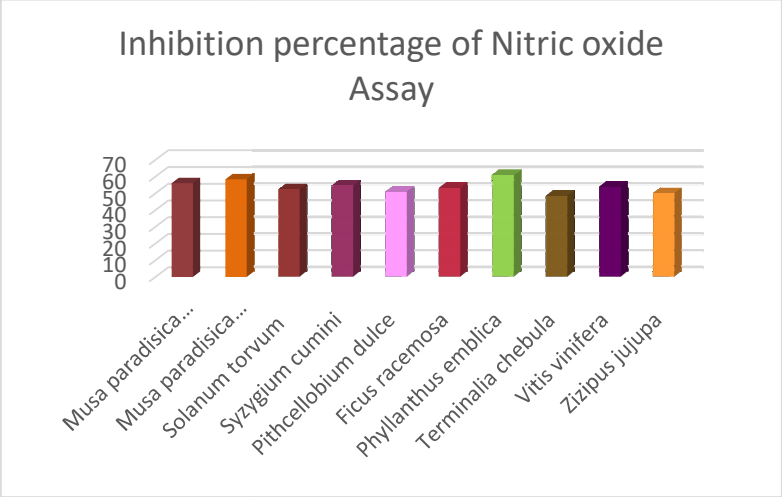

Figure 5 Nitric OxideScavenging Assayof different samples.

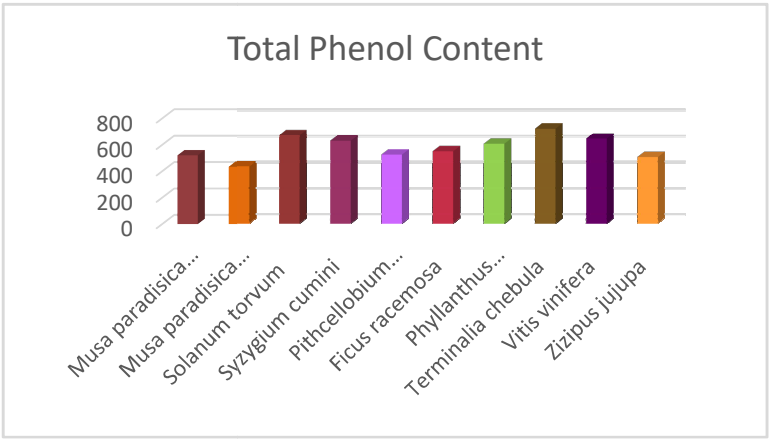

Figure6 Total Phenol Content of different samples.

Table 1(DPPH) 2,2-Diphenyl-1-picrylhydrazyl Free Radical Scavenging Activity of different samples.

Sample	Concentration (µl)	OD value	Inhibition %
Musa paradisica(Flower)	200	0.202	68.53
Musa paradisica(Fruit)	200	0.290	54.83
Solanum torvum	200	0.195	69.63
Syzygiumcumini	200	0.160	75.08
Pithcellobium dulce	200	0.156	75.70
Ficus racemosa	200	0.140	78.19
Phyllanthus emblica	200	0.164	74.46
Terminalia chebula	200	0.180	71.96
Vitis vinifera	200	0.187	70.90
Zizipusjujupa	200	0.130	79.75

Table 2 FRAP (Ferric Reducing Antioxidant Power) of different samples.

Sample	Concentration (µl)	OD value	Inhibition %
Musa paradisica(Flower)	200	0.105	75.47
Musa paradisica(Fruit)	200	0.138	67.76

Solanum torvum	200	0.190	55.60
Syzygiumcumini	200	0.226	47.20
Pithcellobium dulce	200	0.112	73.83
Ficus racemosa	200	0.142	66.82
Phyllanthus emblica	200	0.162	62.15
Terminalia chebula	200	0.152	64.49
Vitis vinifera	200	0.110	74.30
Zizipusjujupa	200	0.128	70.09

Table 3 Hydrogen Peroxide Scavenging Assayof different samples.

Sample	**Concentration (µl)**	**OD value**	**Inhibition %**
Musa paradisica(Flower)	200	0.123	65.06
Musa paradisica(Fruit)	200	0.144	59.09
Solanum torvum	200	0.130	63.07
Syzygiumcumini	200	0.161	54.26
Pithcellobium dulce	200	0.202	42.61
Ficus racemosa	200	0.166	52.84
Phyllanthus emblica	200	0.152	56.82
Terminalia chebula	200	0.142	59.66
Vitis vinifera	200	0.135	61.65
Zizipusjujupa	200	0.178	49.43

Table 4 Superoxide Scavenging Assayof different samples.

Sample	**Concentration (µl)**	**OD value**	**Inhibition %**
Musa paradisica (Flower)	200	0.185	69.17
Musa paradisica (Fruit)	200	0.195	67.50
Solanum torvum	200	0.162	73.00
Syzygiumcumini	200	0.178	70.33
Pithcellobium dulce	200	0.158	73.67
Ficus racemosa	200	0.123	79.50
Phyllanthus emblica	200	0.175	70.83
Terminalia chebula	200	0.202	66.33
Vitis vinifera	200	0.210	65.00
Zizipusjujupa	200	0.183	69.50

Table 5 Nitric OxideScavenging Assayof different samples.

Sample	**Concentration (µl)**	**OD value**	**Inhibition %**
Musa paradisica (Flower)	200	0.285	56.15
Musa paradisica (Fruit)	200	0.270	58.46
Solanum torvum	200	0.310	52.31
Syzygiumcumini	200	0.295	54.61
Pithcellobium dulce	200	0.320	50.77
Ficus racemosa	200	0.305	53.07
Phyllanthus emblica	200	0.255	60.77
Terminalia chebula	200	0.335	48.46
Vitis vinifera	200	0.300	53.85
Zizipusjujupa	200	0.325	50.00

Table 6 Total Phenol Content of different samples.

Sample	Concentration (µl)	OD value	TPC (µg GAE/ml)
Musa paradisica(Flower)	200	0.646	522
Musa paradisica(Fruit)	200	0.542	435
Solanum torvum	200	0.832	676
Syzygiumcumini	200	0.781	633
Pithcellobium dulce	200	0.654	528
Ficus racemosa	200	0.685	553
Phyllanthus emblica	200	0.752	610
Terminalia chebula	200	0.890	725
Vitis vinifera	200	0.800	650
Zizipusjujupa	200	0.632	510

Conclusion:-

The Present investigation systematically evaluated the antioxidant potential of ten selected native fruits and medicinal plants, namely Musa paradisiaca (Flower and Fruit), Solanum torvum, Syzygiumcumini, Pithecellobium dulce, Ficus racemosa, Phyllanthus emblica, Terminalia chebula, Vitis vinifera, and Ziziphus jujuba. A battery of in vitro assays—DPPH radical scavenging, FRAP assay, hydrogen peroxide scavenging, superoxide radical scavenging, nitric oxide scavenging, and total phenolic content determination—were employed to provide a comprehensive assessment of antioxidant efficacy. The findings revealed significant variations across species, yet underscored the role of polyphenols and flavonoids as key contributors to free-radical neutralization.

Across assays, Ficus racemosa consistently exhibited the highest antioxidant activity, particularly in the hydroxyl and superoxide radical scavenging assays, where its inhibition reached 79.50%. This superior performance corroborates earlier findings reporting the abundance of phenolics and tannins in Ficus racemosa bark and fruit, which are potent scavengers of free radicals (Kumar, Sandhir, & Ojha, 2014). Similarly, Phyllanthus emblica emerged as a strong inhibitor in the nitric oxide scavenging assay (60.77%), aligning with its well-documented richness in vitamin C and hydrolysable tannins that contribute to oxidative stress mitigation (Singh, Singh, Kumar, & Arora, 2012).

Terminalia chebula displayed the maximum total phenolic content (725 µg GAE/ml), highlighting the strong correlation between phenolic abundance and antioxidant potential, as previously emphasized by Dudonné, et.al.,(2009). Although its nitric oxide scavenging activity was lower in this study (48.46%), this discrepancy may be attributable to differences in extraction solvents, plant maturity, or assay sensitivity (Sabu &Kuttan, 2002). The observed variations illustrate the complexity of antioxidant assays and the importance of using multiple complementary approaches (Prior, Wu, & Schaich, 2005).

Moderate but consistent activity was recorded for Musa paradisiaca (Flower and Fruit) and Syzygiumcumini. Both species demonstrated inhibition values between 54–70% in most radical scavenging assays, consistent with the presence of flavonoids and anthocyanins that confer appreciable but assay-dependent antioxidant activity (Singh, et.al.,2016; Sharma, et.al.,2013). Vitis vinifera also exhibited high phenolic content (650 µg GAE/ml), reinforcing earlier reports that link resveratrol and proanthocyanidins in grapes to antioxidant capacity (Rajan, et.al., 2020).
The combined outcomes suggest that the tested plants are valuable sources of natural antioxidants, with Ficus racemosa, Phyllanthus emblica, and Terminalia chebula being particularly potent. These results are in strong agreement with prior studies that highlight the relationship between dietary polyphenols and reduced risk of chronic diseases associated with oxidative stress, such as cardiovascular disorders, diabetes, and neurodegeneration (Halliwell & Gutteridge, 2015; Scalbert, Johnson, & Saltmarsh, 2005).

Overall, this work contributes to the growing body of literature demonstrating that native fruits and vegetables are rich repositories of bioactive compounds with significant antioxidant properties. Importantly, the correlation between high total phenolic content and radical scavenging capacity underscores the central role of phenolics in combating oxidative damage. These findings advocate for the inclusion of these traditional fruits and vegetables in regular diets as functional foods to promote health and longevity. Furthermore, they provide a scientific foundation

for future research directed toward isolating, characterizing, and commercializing novel antioxidant compounds from these sources.

In conclusion, this study not only validates the ethnomedicinal significance of the investigated species but also highlights their potential application in nutraceuticals and pharmaceutical formulations. By bridging traditional knowledge with modern antioxidant assays, the present investigation supports the sustainable utilization of native biodiversity in addressing global health challenges posed by oxidative stress.

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