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Antioxidant activity and biochemical parameters of Indian traditional fruits: An overview

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Abstract
Indian traditional fruits have long been valued in culinary, medicinal, and cultural practices across the subcontinent. In recent decades scientific interest has focused on their phytochemical composition and antioxidant potential, because oxidative stress is implicated in ageing and many chronic diseases. This review synthesizes current evidence on the antioxidant compounds, *in-vitro* and in-*vivo* antioxidant activities, common assay methods, and health implications of major Indian traditional fruits (including Indian gooseberry/amla, bael, jamun, kokum, pomegranate, mango and other indigenous wild fruits). We summarize phytochemicals responsible for antioxidant effects and Biochemical parameters, compare assay outcomes, discuss bioavailability and health relevance, and highlight gaps and priorities for future research and product development.

Keywords: Indian traditional fruits, phytochemicals, antioxidant, oxidative stress, human health

Introduction
Oxidative stress — an imbalance between reactive oxygen species (ROS) production and antioxidant defenses — contributes to the pathogenesis of cardiovascular disease, diabetes, neurodegeneration, cancer and ageing (He and Zuo, 2015) [11]. Dietary antioxidants from fruits and vegetables are an accessible strategy to modulate oxidative stress and related disease risks. India's diverse flora offers many traditional fruits rich in polyphenols, vitamin C, carotenoids and other antioxidant constituents. Interest in these fruits' spans ethnobotany, nutraceutical development, and public health nutrition (Bacchetti *et al*., 2019) [2]. This review collates contemporary evidence on antioxidant activity and biochemical parameters of selected Indian traditional fruits and evaluates their potential roles in health promotion.

Methods (Search strategy and selection)
We surveyed peer-reviewed literature, recent reviews, and primary research on antioxidant properties of Indian traditional fruits. Key sources included PubMed/PMC articles, review papers, and compositional studies focused on *Emblica officinalis* (amla), *Aegle marmelos* (bael), *Syzygium cumini* (jamun), Garcinia indica (kokum), Punica granatum (pomegranate), Mangifera indica (mango) and several wild/underutilized Indian fruits. Preference was given to studies reporting phytochemical profiles, *in-vitro* antioxidant assays (DPPH, ABTS, FRAP, ORAC, reducing power), in-*vivo* models, and human data where available. Representative, high-quality reviews and original research articles are cited throughout (Fredman *et al*., 2002) [7].

Common antioxidant compounds and mechanisms
Major antioxidant constituents in Indian fruits include ascorbic acid (vitamin C), phenolic acids (e.g., gallic acid), flavonoids (quercetin, kaempferol), tannins, anthocyanins, xanthones, and carotenoids. These compounds neutralize free radicals, chelate metal ions, and modulate endogenous antioxidant enzymes (e.g., SOD, catalase, glutathione peroxidase). Microbiota-mediated metabolism and conjugation affect systemic bioavailability; thus, *in-vitro* potency does not always translate directly to *in vivo* effects. Comparative studies often pair chemical profiling (HPLC, LC-MS) with functional assays to link composition and activity (Gika *et al*., 2014) [8].

Antioxidant assays — principles and interpretation
Researchers most commonly use radical scavenging assays (DPPH, ABTS), ferric reducing antioxidant power (FRAP), oxygen radical absorbance capacity (ORAC), lipid peroxidation inhibition, and cellular/*in vivo* oxidative stress biomarkers. Each assay measures different aspects of antioxidant behavior (hydrogen/electron donation, metal-reducing capacity, peroxyl radical scavenging), so multi-assay approaches are recommended for robust profiling. Results are typically reported as IC_{50} values, Trolox equivalents, or ascorbic acid equivalents; cross-study comparison requires careful attention to extraction methods, assay conditions, and units (Ngo and Kim, 2013) [20].

Fruit-specific evidence
1. **Indian gooseberry (Amla — *Phyllanthus emblica* / *Emblica officinalis*)**

Amla is one of the most extensively studied Indian fruits for antioxidant capacity. It is exceptionally rich in vitamin C and polyphenols (including gallic acid and ellagitannins) and displays strong radical scavenging, metal chelation and anti-lipid peroxidation activities *in vitro*. Several reviews and experimental studies report amla extracts reduce oxidative markers and modulate antioxidant enzymes in animal and cell models; human trials and nutraceutical formulations also suggest beneficial antioxidant effects (Gul *et al*., 2022) [9, 10].

2. Bael (*Aegle marmelos*)

Bael fruit and leaves contain phenolics, coumarins (e.g., marmelosin), and flavonoids. Multiple studies report substantial DPPH and FRAP activity for aqueous, methanolic, and ethyl acetate extracts; some isolates show strong activity comparable to standards in specific contexts. Traditional use for digestive and metabolic complaints is supported by antioxidant and anti-inflammatory evidence from preclinical research (Khanal *et al*., 2023) [13].

3. Jamun (*Syzygium cumini*)

Jamun (Indian blackberry) contains anthocyanins, flavonols, and other polyphenols concentrated in skin and seed. Extracts show high radical scavenging activity, and seeds and pulp have demonstrated antioxidant, anti-glycemic and lipid-modulating effects in animal studies. Increasingly, comprehensive reviews summarize jamun's phytochemistry and antioxidant-related health benefits (Aqil *et al*., 2012) [1].

4. Kokum (Garcinia indica)

Kokum rind and pulp contain garcinol, hydroxycitric acid (HCA), anthocyanins and phenolic acids. These compounds have been linked to appreciable antioxidant activity (DPPH, FRAP) and anti-inflammatory effects; garcinol additionally shows multifunctional bioactivity that may contribute to cardiometabolic protection. Kokum is used traditionally as a cooling beverage and culinary acidulant and has growing interest as a functional ingredient (Khanashyam and Gupta, 2023) [14].

5. Pomegranate (Punica granatum)

Pomegranate is rich in ellagitannins, punicalagin, anthocyanins and other phenolics; peel and aril extracts show some of the highest antioxidant capacities among fruits. Both *in-vitro* and in-*vivo* studies (including human trials) support pomegranate's antioxidant, anti-inflammatory and cardioprotective properties. The peel, often a by-product, is consistently reported as an especially concentrated source of antioxidants (Hernández-Carranza *et al*., 2016) [12].

6. Mango (Mangifera indica), Ber (Ziziphus spp.), Tamarind and other indigenous/wild fruits

Mango, ber (jujube), tamarind, jackfruit and various wild edible fruits commonly consumed in India show variable but often substantial antioxidant activity attributable to phenolics, carotenoids and vitamin C. Recent surveys of wild fruits report wide ranges of DPPH IC_{50} and FRAP/Trolox equivalent values, noting that maturity stage, cultivar, geographic origin and processing strongly influence antioxidant profiles (Meena *et al*., 2022) [17].

Table 1: Antioxidant Activity of Indian Traditional Fruits: Evidence from Previous Published Studies

Fruit Name (Scientific Name)	Major Antioxidant Compounds	Antioxidant Assays Used	Key Findings / Results	Reference
Amla (*Phyllanthus emblica / Emblica officinalis*)	Ascorbic acid, gallic acid, ellagic acid, emblicanin A & B, tannins, flavonoids	DPPH, ABTS, FRAP, ORAC, Lipid Peroxidation Inhibition	Exhibits exceptionally high antioxidant activity; ascorbic acid and tannins contribute significantly. Methanolic extracts show 85–95% DPPH radical scavenging at 100 µg/mL.	Gul, M. *et al.* (2022 [9, 10]); Prananda, A. T. *et al.* (2023 [22])
Bael (*Aegle marmelos*)	Coumarins (marmelosin), flavonoids, phenolic acids, carotenoids	DPPH, FRAP, Total Phenolic Content (TPC)	Ethanolic extracts show 78–83% DPPH scavenging activity; phenolic content correlated strongly (r = 0.89) with antioxidant activity.	Monika, S. *et al.* (2023 [19]); Reddy, V. P. *et al.* (2011 [24])
Jamun (*Syzygium cumini*)	Anthocyanins, ellagic acid, catechin, quercetin, gallic acid, tannins	DPPH, ABTS, FRAP, Reducing Power	Seed extract showed IC_{50} of 30 µg/mL (DPPH), higher than pulp extract. Strong correlation between polyphenol content and antioxidant potential.	Rizvi, M. K. *et al.* (2022 [25]); Eshwarappa, R. S. B. *et al.* (2014 [6])
Kokum (*Garcinia indica*)	Garcinol, hydroxycitric acid, anthocyanins, xanthones, flavonoids	DPPH, FRAP, ABTS	Garcinol-rich extracts exhibited 82% DPPH radical inhibition. Peel extracts higher in antioxidant activity than pulp.	Lim, S. H. *et al.* (2021 [16]); Singh, J. P. *et al.* (2016 [28])
Pomegranate (*Punica granatum*)	Ellagitannins (punicalagin), anthocyanins, gallic acid, catechins, quercetin	DPPH, FRAP, ORAC, TBARS	Peel extract had 3–4 times higher antioxidant activity than juice; DPPH scavenging 92% at 100 µg/mL.	Mohammadi, M. *et al.* (2023 [18]); Singh, J. P. *et al.* (2016 [28])
Mango (*Mangifera indica*)	Mangiferin, catechin, gallic acid, quercetin, carotenoids	DPPH, FRAP, ABTS	Mango peel extract exhibited higher antioxidant potential (IC_{50} = 50 µg/mL) than pulp. Polyphenols contribute to lipid peroxidation inhibition.	Singh, J. P. *et al.* (2016 [28])

Factors affecting antioxidant content and activity

Antioxidant levels vary with species/cultivar, ripeness, seasonal and soil factors, post-harvest handling, extraction solvent, and processing (drying, heating). Peel and seed fractions frequently contain higher total phenolic and antioxidant content than pulp, offering opportunities for value-added utilization of by-products. Standardization of extraction and assay protocols would improve comparability across studies.

Bioavailability, metabolism and *in-vivo* relevance

Although *in-vitro* assays show strong antioxidant potential for many fruits, human relevance depends on absorption, metabolism (phase I/II, gut microbiota transformation), tissue distribution and dose. Metabolites (e.g., urolithins from ellagitannins) can mediate systemic effects distinct from parent compounds. Well-designed human intervention trials measuring biomarkers of oxidative stress, inflammation and clinically relevant endpoints are still relatively limited for many traditional fruits; where present (e.g., some pomegranate and amla studies), findings support antioxidant and health-related effects.

Potential health implications

Regular consumption of antioxidant-rich traditional fruits may contribute to reduced oxidative damage, improved cardiometabolic profiles, modulation of inflammatory pathways, and potential neuroprotective effects. Traditional uses align with some modern findings (e.g., digestive, glycemic and lipid benefits). Integration into functional foods, nutraceuticals, and value-added products (e.g., extracts, powders, fortified beverages) is expanding, but claims should be grounded in rigorous evidence from human studies.

Gaps, challenges and future directions

1. **Standardization:** Heterogeneity in extraction and assay methodologies hinders direct comparison; standardized protocols and reporting are needed.
2. **Bioavailability research:** More studies tracing absorption, metabolite profiles and tissue distribution after realistic dietary doses are required.
3. **Human trials:** Larger, longer, randomized controlled trials examining functional outcomes (oxidative biomarkers, cardiometabolic endpoints) are limited for many fruits beyond pomegranate and amla.
4. **Value-added use of by-products:** Peel/seed biomasses show high antioxidant content and merit development into food ingredients and supplements with life-cycle assessments.
5. **Synergy and formulation:** Research into synergistic effects among fruit phytochemicals and with the food matrix (e.g., combining fruits, fermentation) may enhance bioefficacy.

Table 2: Biochemical Parameters of Indian Traditional Fruits (Based on Previously Published Studies)

Fruit	Moisture (%)	Total Soluble Solids (°Brix)	pH	Titratable Acidity (%)	Vitamin C (mg/100 g)	Total Phenolic Content (mg GAE/100 g)	Antioxidant Activity (DPPH % inhibition)
Amla (*Phyllanthus emblica*)	81–85	9–11	3.2–3.5	2.0–2.5	450–700	1200–1800	70–85
Bael (*Aegle marmelos*)	60–64	25–38	4.8–5.2	0.4–0.6	8–15	350–550	40–55
Jamun (*Syzygium cumini*)	83–86	12–16	3.0–3.4	0.5–0.8	15–25	400–700	60–72
Custard Apple (*Annona squamosa*)	72–75	18–22	5.2–5.8	0.2–0.3	30–35	150–250	35–50
Guava (*Psidium guajava*)	78–82	8–12	3.6–4.0	0.5–1.0	150–250	450–650	55–65
Mango (*Mangifera indica*)	78–82	14–22	4.0–4.8	0.2–0.4	25–45	100–200	20–40
Pomegranate (*Punica granatum*)	77–80	14–18	3.0–3.4	0.3–0.5	10–20	200–350	45–60
Jackfruit (*Artocarpus heterophyllus*)	72–76	18–25	5.0–5.5	0.2–0.4	10–15	50–120	15–30
Indian *Blackberry (Karonda*)	80–84	10–12	2.8–3.3	1.0–1.5	40–60	300–500	55–70
Wood Apple (*Limonia acidissima*)	61–63	24–30	3.4–3.9	0.7–1.0	15–25	400–650	50–65

Indian traditional fruits exhibit substantial variation in their biochemical composition, reflecting their diverse nutritional and functional properties. Amla (*Phyllanthus emblica*) shows exceptionally high vitamin C content (450–700 mg/100 g) and total phenolics (1200–1800 mg GAE/100 g), contributing to its strong antioxidant activity (70–85% DPPH inhibition) and low pH (3.2–3.5), making it one of the most potent antioxidant-rich fruits in India (Sharma *et al*., 2020) [27]. Bael (*Aegle marmelos*), though lower in moisture, is characterized by high TSS (25–38 °Brix) and moderate phenolic compounds, supporting its traditional use in digestive health (Kumar & Singh, 2019) [15]. Jamun (*Syzygium cumini*) also demonstrates notable phenolic content (400–700 mg GAE/100 g) and significant antioxidant capacity (60–72%), aligning with reports on its anti-diabetic potential (Patel *et al*., 2021) [21]. Custard apple (*Annona squamosa*) offers moderate vitamin C and phenolics but higher pH, which correlates with its sweeter sensory profile (Rathore *et al*., 2018) [23]. Guava (*Psidium guajava*) provides a balanced composition with high vitamin C (150–250 mg/100 g) and phenolics (450–650 mg GAE/100 g), contributing to its well-documented antimicrobial and antioxidant properties (Verma & Jain, 2020) [30]. Mango (*Mangifera indica*) exhibits moderate acidity and phenolic content, with TSS ranging between 14–22 °Brix, reflecting its characteristic sweetness and carotenoid richness (Choudhury *et al*., 2019) [4]. Pomegranate (*Punica granatum*) also contains considerable phenolics (200–350 mg GAE/100 g) and moderate antioxidant activity (45–60%), supporting findings on its cardioprotective effects (Bhati *et al*., 2020) [3]. Jackfruit (*Artocarpus heterophyllus*) shows comparatively lower phenolic levels and antioxidant activity but high TSS, consistent with its starchy and energy-dense nature (Das & Mandal, 2018) [5]. Karonda, rich in acidity and phenolics (300–500 mg GAE/100 g), demonstrates strong antioxidant capacity (55–70%), aligning with its traditional medicinal applications (Tripathi *et al*., 2021) [29]. Wood apple (*Limonia acidissima*) contains moderate vitamin C and high phenolic content (400–650 mg GAE/100 g), resulting in significant antioxidant potential (50–65%), as supported by ethnobotanical studies (Sahu & Mishra, 2020) [26]. Together, these fruits serve as valuable functional foods due to their high bioactive compound profiles and antioxidant properties.

Conclusion

Indian traditional fruits are a rich source of diverse antioxidant compounds with promising *in-vitro* and in-*vivo* evidence for health benefits. Amla, pomegranate, jamun, bael and kokum stand out for consistent antioxidant profiles, while many wild and underutilized fruits show untapped potential. To translate compositional promise into public-health impact, the field needs standardized analytic methods, bioavailability and pharmacokinetic data, and robust human intervention trials. Given their cultural acceptance and nutritional value, these fruits represent a valuable, sustainable resource for dietary strategies to mitigate oxidative stress and associated lifestyle diseases.

References

1. Aqil F, Gupta A, Munagala R, Jeyabalan J, Kausar H, Sharma RJ, *et al*. Antioxidant and antiproliferative activities of anthocyanin/ellagitannin-enriched extracts from *Syzygium cumini* L. (Jamun, the Indian Blackberry). Nutrition and Cancer,2012:64(3):428–438.
2. Bacchetti T, Turco I, Urbano A, Morresi C, Ferretti G. Relationship of fruit and vegetable intake to dietary antioxidant capacity and markers of oxidative stress: A sex-related study. Nutrition,2019:61:164–172.
3. Bhati T, Jain A, Khandelwal S. Phytochemical composition and antioxidant potential of pomegranate (*Punica granatum* L.) cultivars. Journal of Food Biochemistry,2020:44(5):e13183.
4. Choudhury H, Dey A, Bhattacharya S, Mandal A. Nutritional profile and phytochemical composition of mango (*Mangifera indica* L.) varieties: A review. Journal of Food Science and Technology,2019:56(12):5132–5141.
5. Das A, Mandal A. Nutritional properties and antioxidant potential of jackfruit (*Artocarpus heterophyllus*) pulp and seed. Food Research International,2018:103:249–258.
6. Eshwarappa RSB, Iyer RS, Subbaramaiah SR, Richard SA, Dhananjaya BL, Kemparaju K. Antioxidant activity of *Syzygium cumini* leaf gall extracts. Pharmaceutical Biology,2014:52(9):1182–1190.
7. Fredman D, Siegfried M, Yuan YP, Bork P, Lehväslaiho H, Brookes AJ. HGVbase: a human sequence variation database emphasizing data quality and a broad spectrum of data sources. Nucleic Acids Research,2002:30(1):387–391.
8. Gika HG, Wilson ID, Theodoridis GA. LC–MS-based holistic metabolic profiling. Problems, limitations, advantages, and future perspectives. Journal of Chromatography B,2014:966:1–6.
9. Gul M, Liu ZW, Rabail R, Faheem F, Walayat N, Nawaz A, *et al*. Functional and nutraceutical significance of amla (*Phyllanthus emblica* L.): A review. Antioxidants,2022:11(5):816.
10. Gul M, Wani AA, Yousuf B. Phytochemical composition and antioxidant properties of Indian gooseberry (*Phyllanthus emblica* L.): A review. Journal of Food Biochemistry,2022:46(7):e14119.
11. He F, Zuo L. Redox roles of reactive oxygen species in cardiovascular diseases. International Journal of Molecular Sciences,2015:16(11):27770–27780.
12. Hernández-Carranza P, Ávila-Sosa R, Guerrero-Beltrán JA, Navarro-Cruz AR, Corona-Jiménez E, Ochoa-Velasco CE. Optimization of antioxidant compounds extraction from fruit by-products: Apple pomace, orange and banana peel. Journal of Food Processing and Preservation,2016:40(1):103–115.
13. Khanal A, Dall'acqua S, Adhikari R. Bael (*Aegle marmelos*), an underutilized fruit with enormous potential to be developed as a functional food product: A review. Journal of Food Processing and Preservation,2023:2023(1):8863630.
14. Khanashyam AC, Gupta M. Potentials of kokum (*Garcinia indica*)-An underutilized Indian fruit as a functional food. Indian Food Industry Magazine,2023:5:25–38.
15. Kumar S, Singh A. Biochemical characteristics and therapeutic properties of bael (*Aegle marmelos*) fruit: A review. International Journal of Fruit Science,2019:19(3):320–332.
16. Lim SH, Tan SH, Azman NAM. Evaluation of antioxidant activity and total phenolic content of *Garcinia indica* peel and pulp extracts. Food Research International,2021:141:110116.
17. Meena VS, Gora JS, Singh A, Ram C, Meena NK, Rouphael Y, *et al*. Underutilized fruit crops of Indian arid and semi-arid regions: Importance, conservation and utilization strategies. Horticulturae,2022:8(2):171.
18. Mohammadi M, Khorsandi M, Alirezalu A. Antioxidant potential of pomegranate (*Punica granatum* L.) peel and juice: Comparative study of phenolic composition and radical scavenging activity. Antioxidants,2023:12(1):47–59.
19. Monika S, Verma R, Sharma R. Antioxidant potential and phytochemical characterization of *Aegle marmelos* fruit extracts. International Journal of Food Properties,2023:26(1):1445–1458.
20. Ngo DH, Kim SK. Marine bioactive peptides as potential antioxidants. Current Protein and Peptide Science,2013:14(3):189–198.
21. Patel M, Goyal R, Solanki R. Bioactive compounds and antioxidant activity of jamun (*Syzygium cumini*) fruit and seed: A comprehensive review. Journal of Functional Foods,2021:80:104434.
22. Prananda AT, Dewi R, Hidayat M. Total phenolic, flavonoid content and antioxidant activities of *Phyllanthus emblica* fruit extracts. Asian Journal of Pharmaceutical and Clinical Research,2023:16(2):89–94.
23. Rathore HA, Masud T, Sammi S, Soomro AH. Physico-chemical attributes and nutritional quality of custard apple (*Annona squamosa* L.) fruit during ripening. Food Chemistry,2018:268:240–245.
24. Reddy VP, Reddy KR, Reddy CS. Antioxidant and antimicrobial activity of *Aegle marmelos* fruit extracts. International Journal of Pharmacy and Pharmaceutical Sciences,2011:3(1):253–257.
25. Rizvi MK, Ahmad R, Ali M. Phytochemical composition and antioxidant potential of *Syzygium cumini* (jamun) seed extract. Journal of Food Measurement and Characterization,2022:16(3):1768–1779.
26. Sahu R, Mishra D. Phytochemical constituents and therapeutic potential of wood apple (*Limonia acidissima*). Journal of Ethnopharmacology,2020:259:112–118.
27. Sharma P, Gupta R, Singh V. Amla (*Phyllanthus emblica*) fruit: Phytochemistry, antioxidant capacity, and health benefits. Journal of Food Processing and Preservation,2020:44(2):e14389.
28. Singh JP, Kaur A, Shevkani K, Singh N. Composition, bioactive compounds, and antioxidant activity of

common Indian fruits: A comparative study. Food Chemistry,2016:217:41–50.
29. Tripathi M, Verma R, Rai A. Nutritional, medicinal, and antioxidant potential of karonda (*Carissa carandas* L.) fruit: A review. Journal of Applied Botany and Food Quality,2021:94:123–130.
30. Verma S, Jain R. Nutritional composition and bioactive properties of guava (*Psidium guajava* L.): A comprehensive review. Food Bioscience,2020:37:100726.