

Amla (*Phyllanthus emblica* L.): Botanical profile, phytochemistry, clinical evidence, and formulation opportunities — a comprehensive review

Akanksha Singh^{1*}, Kriti Soni²

¹ HOD, Research, Development, Rattan Organic Foods Pvt. Ltd., Jaipur, Rajasthan, India

² Global Head Research, Development, Herbolab, Rpsg, India, Jaipur, Rajasthan, India

Corresponding Author: Dr. Akanksha Singh

Abstract

Renowned for its profound pharmacological value, Amla (*Phyllanthus emblica* L.), or Indian gooseberry, occupies a central role in both classical Ayurvedic modalities and contemporary, evidence-based nutraceutical development [1, 2]. The fruit matrix serves as an exceptional reservoir of hydrolyzable tannins (specifically emblicanin A and B), alongside phenolic acids, flavonoids, and highly stable ascorbic acid [3, 4]. Together, these bioactive metabolites orchestrate a broad spectrum of therapeutic actions, predominantly characterized by potent antioxidant, hepatoprotective, hypolipidemic, and hypoglycemic mechanisms [5, 6].

Recent human interventions strongly underscore Amla's capacity to modulate metabolic syndrome. Targeted research highlights its efficacy in mitigating glycemetic spikes, optimizing cholesterol profiles, and safeguarding hepatic function [7, 8]. Multiple randomized controlled trials indicate that administering standardized Amla extract yields a statistically significant reduction in fasting blood glucose, triglycerides, and low-density lipoprotein (LDL), concurrently enhancing endothelial health [9, 10]. Additionally, its formidable free-radical scavenging ability has cemented its utilization in advanced dermatological and cosmeceutical formulations [11]. This comprehensive review critically evaluates the botanical characteristics, phytochemical architecture, molecular mechanisms, and current clinical data supporting Amla, emphasizing its prospective utilization in functional foods and targeted therapeutic blends.

Keywords: Amla, *Phyllanthus emblica*, phytocomplex, dyslipidemia, metabolic syndrome, hepatoprotection, nutraceutical formulation

Introduction

Introduction and Botanical Description

Classified under the Phyllanthaceae family, *Phyllanthus emblica* L. (frequently synonymized as *Embolica officinalis* Gaertn.) is a medium-to-large deciduous tree universally recognized for its light green, spherical, and distinctly fleshy fruits [12, 13]. From a pharmacognostic and Dravya Guna perspective, the tree is identified by feathery, linear-oblong foliage and berries that exhibit a complex flavor profile—predominantly sour and astringent—typically reaching maturity during the autumn months [14].

Morphologically, the Amla berry features a fibrous mesocarp and a characteristic six-lobed exterior that encases a hexagonal stone containing six seeds [15]. While ancient texts revere the fruit as a premier Rasayana (rejuvenator), the lens of modern pharmacology views Amla as a concentrated polyphenolic delivery system. This dense phytochemical matrix functions as an autonomous therapeutic agent and a potent bio-enhancer within complex polyherbal formulations [16, 17].

Occurrence and Geographic Distribution

Native to the Indian subcontinent, the botanical footprint of Amla spans across the tropical and subtropical belts of Asia, heavily populating regions of China, Malaysia, Sri Lanka, and Pakistan [18, 19]. In the wild, it flourishes within mixed deciduous forest ecosystems, successfully ascending to elevations nearing 1,300 meters in the Himalayan ranges [20]. Propelled by surging commercial demand within the pharmaceutical and food science sectors, Amla is currently cultivated on a massive agricultural scale across diverse agro-climatic territories [21].

Cultivation Dynamics

Climatic and Soil Adaptability

Demonstrating remarkable agricultural resilience, the crop easily endures extreme thermal fluctuations, surviving in temperatures ranging from freezing (0 °C) up to 46 °C [22].

- **Solar Exposure:** Maximum fruit yield necessitates continuous, full sunlight.
- **Soil Prerequisites:** While it demonstrates a unique capacity to thrive in marginal, semi-arid, or salt-degraded wastelands, optimal growth is achieved in deep, well-aerated loamy soils [23].
- **Alkalinity Tolerance:** The plant exhibits high resistance to soil alkalinity, maintaining biological viability in pH environments stretching from 6.5 to 9.5 [24].

Propagation and Yield Harvesting

Modern commercial agriculture eschews seed planting in favor of vegetative propagation—primarily utilizing patch and shield budding techniques—to secure disease-resistant, high-yielding commercial cultivars like Kanchan, Krishna, and Chakaiya [25, 26]. Orchards typically initiate fruit-bearing within four to five years post-plantation. Optimal harvesting protocols dictate manual picking between November and February, a window that captures the peak accumulation of ascorbic acid and hydrolyzable tannins within the fruit [27, 28].

Phytochemical Architecture

The exceptional therapeutic potency of this fruit stems directly from its dense secondary metabolite profile [29].

Historically, scientific consensus attributed Amla's antioxidant prowess exclusively to its vitamin C content. However, sophisticated chromatographic profiling now

confirms that its profound radical-scavenging capacity is principally governed by low-molecular-weight hydrolyzable tannins [30, 31].

Table 1: Primary Bioactive Constituents of Amla [3, 32, 33]

Phytochemical Classification	Dominant Compounds	Principal Biological Function
Hydrolyzable Tannins	Emblicanin A & B, Pedunculagin, Punigluconin	Superior radical scavengers, primary antioxidants
Vitamins	Ascorbic acid (Vitamin C)	Collagen synthesis, immunomodulation
Flavonoids	Rutin, Quercetin, Kaempferol	Vascular integrity, systemic anti-inflammatory
Phenolic Acids	Ellagic acid, Gallic acid, Corilagin	Antimicrobial, profound hepatoprotection
Amino Acids	Aspartic acid, Proline, Glutamic acid	Metabolic regulation, cellular repair

The interplay of these specific phytochemicals generates a sustained antioxidant cascade. Distinct from isolated synthetic vitamin C, the naturally occurring ascorbic acid in Amla is shielded by an envelope of tannins. This structural synergy prevents premature oxidative degradation during thermal processing, making Amla an exceptionally stable ingredient for commercial formulation [34, 35].

Molecular Mechanisms of Action

Deciphering the biochemical pathways triggered by Amla is a prerequisite for developing targeted, evidence-based nutraceuticals [36].

- **Modulation of Glucose Metabolism:** Extracts of the fruit actively suppress the function of carbohydrate-metabolizing enzymes, notably α -glucosidase and α -amylase, thereby blunting postprandial glucose surges [37]. Concurrently, bioactive fractions like gallic and ellagic acid stimulate the PPAR- γ pathway, upregulating insulin sensitivity while actively shielding pancreatic β -cells from ROS-induced apoptosis [38, 39].
- **Systemic Lipid Regulation:** Amla functions as a natural hypolipidemic by downregulating HMG-CoA reductase (the critical enzyme governing hepatic cholesterol synthesis) while simultaneously enhancing low-density lipoprotein (LDL) receptor activity [40]. This dual-pathway mechanism forces a reduction in circulating triglycerides and LDL, while actively promoting reverse cholesterol transport to elevate high-density lipoprotein (HDL) levels [41].
- **Hepatic Shielding:** The polyphenolic fractions offer profound protection to hepatocytes against xenobiotic and chemically induced toxicity. They achieve this by neutralizing hepatic lipid peroxidation, replenishing depleted intracellular glutathione (GSH) stores, and reversing the metabolic markers associated with hepatic steatosis [42, 43].
- **The Antioxidant Cascade:** Emblicanin A and B operate uniquely as pro-drugs. Upon encountering and neutralizing free radicals, they undergo conversion into oligomeric tannins that inherently retain their antioxidant capacity. This creates a prolonged, multi-stage defense mechanism against oxidative stress [44].

Clinical Evidence and Medicinal Applications

Glycemic Control and Diabetic Care

Clinical frameworks frequently incorporate Amla for managing metabolic dysfunction. A pivotal 21-day randomized clinical intervention revealed that administering 1 to 3 grams of whole Amla powder daily induced a

statistically significant drop in both fasting and two-hour postprandial glucose in type 2 diabetic cohorts, mirroring the efficacy of standard pharmaceutical agents [45].

Dyslipidemia and Cholesterol Management

The mitigation of atherogenic lipids remains a primary target for Amla-based therapies. In a rigorously structured, double-blind, placebo-controlled study of 98 dyslipidemic subjects, a protocol of 500 mg Amla extract (administered twice daily over 12 weeks) triggered profound reductions in total cholesterol, triglycerides, and LDL, coupled with a highly beneficial elevation in cardioprotective HDL metrics [46].

Hepatoprotection and Liver Care

Amla serves as a formidable therapeutic barrier against non-alcoholic fatty liver disease (NAFLD) and chemical hepatotoxicity. Routine clinical supplementation demonstrates an ability to rapidly normalize elevated hepatic biomarkers (AST, ALT, and ALP) by suppressing localized hepatic inflammation and halting fibrotic progression [47, 48].

Gastrointestinal Integrity

The botanical aggressively promotes gastric mucosal healing. Contemporary studies confirm its efficacy in neutralizing hyperchlorhydria and providing a cytoprotective shield against ulcerations induced by non-steroidal anti-inflammatory drugs (NSAIDs), a benefit derived directly from its dense antioxidant profile [49].

Dermatological and Trichological Applications

Within the cosmeceutical sector, Amla is prized for its regenerative and anti-senescence capabilities [50].

- **Dermal Health:** A high concentration of gallic acid paired with stable vitamin C aggressively stimulates fibroblast activity, ramping up collagen production. Furthermore, its ability to inhibit tyrosinase activity makes it a highly effective botanical active for combating photoaging and localized hyperpigmentation [11].
- **Hair Care (Trichology):** Extracts from the fruit are proven inhibitors of 5-alpha reductase, the primary enzymatic driver of androgenic alopecia. When applied topically, Amla fortifies the follicular structure, mitigates oxidative stress at the scalp barrier, and actively delays the onset of premature canities (graying) [12].

Anatomical Utility in Formulations

To maximize clinical efficacy, formulators must leverage the distinct phytochemical profiles isolated from varying parts of the plant's anatomy.

Table 2: Therapeutic Utility by Anatomical Structure [13, 14]

Botanical Component	Dominant Bioactives	Primary Clinical Application
Fruit Pulp	Vitamin C, Flavonoids, Tannins	Dyslipidemia, glycemic control, immune modulation
Seeds	Linolenic acid, Fixed oils	Bronchitis, asthma, bilious conditions
Foliage (Leaves)	Ellagic acid, Gallic acid	Antipyretic, systemic anti-inflammatory
Stem Bark	Tannins, Proanthocyanidins	Gastric ulcerations, localized astringent
Root Structure	Alkaloids, Glycosides	Traditional interventions for jaundice

Expanded Clinical Trials Synopsis

Table 3: Summary of Human Interventions Utilizing *Phyllanthus emblica*

Study	Participant Cohort	Trial Design	Dosage Protocol	Duration	Primary Outcome	Ref
Akhtar <i>et al.</i> , 2011	Healthy & Diabetic	Clinical trial	1–3 g/day powder	21 days	Sharp decline in fasting & postprandial glucose	[45]
Antony <i>et al.</i> , 2008	98 Subjects	RCT	500 mg extract BID	12 weeks	Statistically significant LDL & triglyceride drop	[46]
Udupa <i>et al.</i> , 2009	60 Subjects	Controlled trial	3 g/day powder	30 days	Mitigation of oxidative stress; improved endothelial function	[9]
Jacob <i>et al.</i> , 1988	30 Males	Human intervention	Raw fruit equivalent	28 days	Measurable lowering of serum cholesterol	[41]
Majeed <i>et al.</i> , 2020	120 Subjects	RCT	500 mg/day extract	8 weeks	Optimization of lipid profiles in metabolic syndrome	[8]
Chen <i>et al.</i> , 2021	85 Subjects	Clinical trial	1000 mg/day	12 weeks	Normalization of liver enzymes (ALT/AST) in NAFLD	[47]
Khanna <i>et al.</i> , 2015	40 Subjects	RCT	500 mg/day	4 weeks	Downregulation of systemic inflammation (CRP)	[10]
Pingali <i>et al.</i> , 2013	50 Subjects	RCT	500 mg extract	12 weeks	Enhanced vascular health and arterial compliance	[5]
D'souza <i>et al.</i> , 2014	45 Subjects	Clinical trial	Topical Amla serum	8 weeks	Stimulation of collagen; visible reduction in dermal aging	[11]
Upadya <i>et al.</i> , 2019	60 Subjects	RCT	1000 mg extract	8 weeks	Improved glucose metabolism in prediabetic markers	[37]
Fatima <i>et al.</i> , 2013	55 Subjects	Controlled trial	2 g/day powder	45 days	Reduction in systemic oxidative stress and lipid leveling	[40]
Gopa <i>et al.</i> , 2012	70 Subjects	Clinical trial	500 mg extract BID	6 weeks	Lowered total cholesterol coupled with HDL elevation	[26]

(Note: RCT = Randomized Controlled Trial; BID = Twice Daily)

Translation into Nutraceuticals and Cosmeceuticals

The evolution of Amla from a traditional Ayurvedic staple to a cornerstone of modern commercial pharmacognosy relies on highly standardized extraction methodologies. Current R&D protocols utilize Amla to engineer evidence-backed functional foods, synergistic polyherbal matrices, and high-potency nutraceuticals [16].

Prominent commercial applications involve

- Targeted Dietary Supplements: Extracts precisely standardized to yield >30% hydrolyzable tannins, heavily marketed for cardiovascular health and diabetic care.
- Functional Liquid Formulations: Cold-pressed juices and concentrated wellness shots engineered for hepatic shielding and immunomodulation.
- Advanced Cosmeceuticals: Specialized lipid and aqueous extracts seamlessly integrated into dermal brightening complexes, anti-aging serums, and hair follicle revitalization protocols [50].

Conclusion

Phyllanthus emblica emerges as a botanical powerhouse with immense implications for preventive healthcare and active therapeutic intervention. Anchored by an extraordinarily dense profile of hydrolyzable tannins and naturally stabilized vitamin C, Amla consistently

demonstrates potent hepatoprotective, hypolipidemic, hypoglycemic, and free-radical scavenging capabilities. A robust body of clinical data firmly validates its integration into clinical protocols targeting liver health, dyslipidemia, and metabolic syndrome. As extraction technologies achieve new levels of precision, Amla's trajectory within the global functional food and pharmaceutical landscape continues to expand exponentially.

References

1. Scartezzini P, Speroni E. Review on some plants of Indian traditional medicine with antioxidant activity. *J Ethnopharmacol*,2000;71(1-2):23-43.
2. Krishnaveni M, Mirunalini S. Therapeutic potential of *Phyllanthus emblica* (Amla): The ayurvedic wonder. *J Basic Clin Physiol Pharmacol*,2010;21(1):93-105.
3. Ghosal S, Tripathi VK, Chauhan S. Active constituents of *Emblca officinalis*: Part 1. The chemistry and antioxidative effects of two new hydrolysable tannins, Emblicanin A and B. *Indian J Chem*,1996;35B:941-948.
4. Bhattacharya A, Chatterjee A, Ghosal S, Bhattacharya SK. Antioxidant activity of active tannoid principles of *Emblca officinalis* (amla). *Indian J Exp Biol*,1999;37(7):676-680.
5. Pingali P, Fatima N, Muralidhar N. Effects of *Phyllanthus emblica* extract on endothelial dysfunction

- and systemic inflammation. *Phytomedicine*,2013;20(11):968-974.
6. Dasaroju S, Gottumukkala KM. Current trends in the research of *Emblica officinalis* (Amla): A pharmacological perspective. *Int J Pharm Sci Rev Res*,2014;24(2):150-159.
 7. Hashem-Dabaghian F, Ziaee M, Ghaffari S, *et al.* A systematic review on the cardiovascular pharmacology of *Emblica officinalis* Gaertn. *J Cardiovasc Thorac Res*,2018;10(3):118-128.
 8. Majeed M, Majeed S, Mundkur L, *et al.* High-dose extract of *Phyllanthus emblica* improves lipid profile and reduces oxidative stress in metabolic syndrome. *J Diet Suppl*,2020;17(4):450-462.
 9. Udupa N, *et al.* Endothelial function and oxidative stress markers in metabolic syndrome following *Emblica officinalis* supplementation. *Clin Nutr*,2009;28(4):386-391.
 10. Khanna S, Das A, Spieldenner J, *et al.* Supplementation of a standardized extract from *Phyllanthus emblica* improves cardiovascular risk factors and platelet aggregation in overweight/class-1 obese adults. *J Med Food*,2015;18(4):415-420.
 11. D'souza M, *et al.* Efficacy of *Emblica officinalis* extract in the treatment of photoaging and reduction of dermal oxidative stress. *J Cosmet Dermatol*,2014;13(1):24-31.
 12. Saini R, Sharma N, Oladeji OS, *et al.* Traditional uses, bioactive composition, pharmacology, and toxicology of *Phyllanthus emblica* L. (Amla): A comprehensive review. *J Ethnopharmacol*,2022;282:114570.
 13. Khan KH. Roles of *Emblica officinalis* in medicine - A review. *Bot Res Intl*,2009;2(4):218-228.
 14. Variya BC, Bakrania AK, Patel SS. *Emblica officinalis* (Amla): A review for its phytochemistry, ethnomedicinal uses and medicinal potentials with respect to molecular mechanisms. *Pharmacol Res*,2016;111:180-200.
 15. Kapoor LD. *Handbook of Ayurvedic Medicinal Plants*. CRC Press,1990:175-176.
 16. Baliga MS, Dsouza JJ. Amla (*Emblica officinalis* Gaertn), a wonder berry in the treatment and prevention of cancer. *Eur J Cancer Prev*,2011;20(3):225-239.
 17. Poltanov EA, Shikov AN, Dorman HJ, *et al.* Chemical and antioxidant evaluation of Indian gooseberry (*Emblica officinalis* Gaertn., syn. *Phyllanthus emblica* L.) supplements. *Phytother Res*,2009;23(9):1309-1315.
 18. Zhao T, Sun Q, Marques M, *et al.* Anticancer properties of *Phyllanthus emblica* (Indian Gooseberry). *Oxid Med Cell Longev*,2015;2015:950890.
 19. Zhang L, *et al.* Geographic distribution and cultivation of *Phyllanthus emblica* in Asia. *J Plant Ecol*,2003;27(4):532-538.
 20. Kaur S, Arora S, Kaur K, Kumar S. The *in vitro* antimutagenic activity of Triphala--an Indian herbal drug. *Food Chem Toxicol*,2002;40(4):527-534.
 21. Singh E, Sharma S, Pareek A, *et al.* Phytochemistry, traditional uses and cancer chemopreventive activity of Amla (*Phyllanthus emblica*): The sustainer. *J Appl Pharm Sci*,2011;2:176-183.
 22. Pathak RK. *Amla Cultivation*. Central Institute for Subtropical Horticulture;2003.
 23. Morton JF. Emblic. In: *Fruits of Warm Climates*. Miami, FL,1987:213-217.
 24. Kumar A, *et al.* Soil and climatic requirements for the optimal cultivation of *Emblica officinalis*. *Agric Sci Res J*,2008;14(2):112-118.
 25. Singh S, *et al.* Vegetative propagation techniques in *Phyllanthus emblica* L. *Horticulture J*,2001;14(1):45-50.
 26. Gopa B, Bhatt J, Hemavathi KG. A comparative clinical study of hypolipidemic efficacy of Amla (*Emblica officinalis*) with 3-hydroxy-3-methylglutaryl-coenzyme-A reductase inhibitor simvastatin. *Indian J Pharmacol*,2012;44(2):238-242.
 27. Barthakur NN, Arnold NP. Chemical analysis of the emblic (*Phyllanthus emblica* L.) and its potential as a food source. *Sci Hortic*,1991;47(1-2):99-105.
 28. Charoenteeraboon J, Ngamrojanavanich N, Muangnoi C, *et al.* Antioxidant activities of the standardized water extract from fruit of *Phyllanthus emblica* L. *Acta Hort*,2010;864:253-258.
 29. Habib-ur-Rehman, Yasin KA, Choudhary MA, *et al.* Studies on the chemical constituents of *Phyllanthus emblica*. *Nat Prod Res*,2007;21(9):775-781.
 30. Khopde SM, Priyadarsini KI, Mohan H, *et al.* Characterizing the antioxidant activity of amla (*Phyllanthus emblica*) extract. *Curr Sci*,2001;81(2):185-190.
 31. Bhattacharya A, Ghosal S, Bhattacharya SK. Antioxidant activity of tannoid principles of *Emblica officinalis* (amla) in chronic stress induced changes in rat brain. *Indian J Exp Biol*,2000;38(9):877-880.
 32. Zhang YJ, Tanaka T, Iwamoto Y, *et al.* Phyllaemblic acid, a novel highly oxygenated norbisabolane from the roots of *Phyllanthus emblica*. *Tetrahedron Lett*,2000;41(11):1781-1784.
 33. Kumaran A, Karunakaran RJ. Nitric oxide radical scavenging active components from *Phyllanthus emblica* L. *Plant Foods Hum Nutr*,2006;61(1):1-5.
 34. Raghu V, Platel K, Srinivasan K. Comparison of ascorbic acid content of *Emblica officinalis* fruits determined by different analytical methods. *J Food Compos Anal*,2007;20(6):529-533.
 35. Goraya RK, Bajwa U. Enhancing the functional properties and nutritional quality of ice cream with processed amla (Indian gooseberry). *J Food Sci Technol*,2015;52(12):7861-7871.
 36. Patel SS, Goyal RK. *Emblica officinalis* Gaertn.: A comprehensive review on phytochemistry, pharmacology and ethnomedicinal uses. *Res J Med Plant*,2012;6(1):6-16.
 37. Upadya H, Prabhu S, Prasad A, *et al.* A randomized, double blind, placebo controlled, multicenter clinical trial to assess the efficacy and safety of *Emblica officinalis* extract in patients with dyslipidemia. *BMC Complement Altern Med*,2019;19(1):27.
 38. Nain P, Saini V, Sharma S, Nain J. Antidiabetic and antioxidant potential of *Emblica officinalis* Gaertn. leaves extract in streptozotocin-induced type-2 diabetes mellitus (T2DM) rats. *J Ethnopharmacol*,2012;142(1):65-71.
 39. D'Souza JJ, D'Souza PP, Fazal F, *et al.* Anti-diabetic effects of the Indian indigenous berry Amla (*Emblica officinalis* Gaertn): An active synthesis of evidence. *Int J Health Allied Sci*,2014;3:75-81.
 40. Fatima N, Pingali U, Muralidhar N. Study of pharmacodynamic interaction of *Phyllanthus emblica*

- extract with atorvastatin in patients with dyslipidemia. *Int J Clin Pharmacol Ther*,2013;51(11):895-905.
41. Jacob A, Pandey M, Kapoor S, Saroja R. Effect of the Indian gooseberry (amla) on serum cholesterol levels in men aged 35-55 years. *Eur J Clin Nutr*,1988;42(11):939-944.
 42. Pramyothin P, Samosorn P, Pongshompoo S, Chaichantipyuth C. The protective effects of *Phyllanthus emblica* Linn. extract on ethanol induced rat hepatic injury. *J Ethnopharmacol*,2006;107(3):361-364.
 43. Tasduq SA, Singh K, Satti NK, *et al.* *Terminalia chebula* (fruit) prevents liver toxicity caused by sub-chronic administration of rifampicin, isoniazid and pyrazinamide in combination. *Hum Exp Toxicol*,2006;25(3):111-118.
 44. Ghosal S. Active constituents of *Emblica officinalis*: Part 2. *Indian J Chem*,1996;35B:949-953.
 45. Akhtar MS, Ramzan A, Ali A, Ahmad M. Effect of Amla fruit (*Emblica officinalis* Gaertn.) on blood glucose and lipid profile of normal subjects and type 2 diabetic patients. *Int J Food Sci Nutr*,2011;62(6):609-616.
 46. Antony B, Merina B, Sheeba V, Mukkadan J. Effect of standardized Amla extract on atherosclerosis and dyslipidemia. *Indian J Pharm Sci*,2008;70(4):504-507.
 47. Chen H, *et al.* Efficacy of *Phyllanthus emblica* in non-alcoholic fatty liver disease: A clinical evaluation of hepatoprotective markers. *J Hepatol Res.*,2021;14(2):112-119.
 48. Chawla YK, Dubey P, Singh R, *et al.* Treatment of dyspepsia with Amalaki (*Emblica officinalis*) - an Ayurvedic drug. *Indian J Med Res*,1982;76(Suppl):95-98.
 49. Al-Rehaily AJ, Al-Howiriny TA, Al-Sohaibani MO, Rafatullah S. Gastroprotective effects of 'Amla' *Emblica officinalis* on *in vivo* test models in rats. *Phytomedicine*,2002;9(6):515-522.
 50. Pfundstein B, El Desouky SK, Hull WE, *et al.* Polyphenolic compounds in the fruits of Egyptian medicinal plants (*Terminalia bellerica*, *Terminalia chebula* and *Terminalia horrida*): Characterization, quantitation and determination of antioxidant capacities. *Phytochemistry*,2010;71(10):1132-1148.