Journal of Integral Sciences

[An International Open Access Journal]

Available at www.jisciences.com ISSN: 2581-5679

ANNONA MURICATA (SOURSOP): THE NATURAL ENEMY OF CANCER – A COMPREHENSIVE REVIEW

Bhimavarapu Bhanu Teja, Patibandla Jahnavi*, A. Suneetha, Talari Venkata Sai Jaideep

KVSR Siddhartha College of Pharmaceutical Sciences, Vijayawada, Andhra Pradesh, India.

Received: 14 June 2025 Revised: 27 June 2025 Accepted: 22 July 2025

Abstract

Annona muricata (commonly known as soursop or graviola) is a tropical plant widely recognized for its traditional medicinal applications and growing scientific interest, particularly for its anticancer potential. This review presents a comprehensive analysis of the phytochemical profile, pharmacological activities, and mechanisms underlying the anticancer effects of *A. muricata*. The plant is rich in annonaceous acetogenins, alkaloids, flavonoids, and phenolic compounds, with acetogenins such as annonacin and bullatacin demonstrating potent cytotoxicity against various cancer cell lines including breast, prostate, colon, pancreatic, and liver cancers. Mechanistically, these compounds induce apoptosis through mitochondrial dysfunction, arrest cell cycle progression, and inhibit key signaling pathways such as NF-κB and VEGF, effectively suppressing tumor growth and angiogenesis. Preclinical in vivo studies have confirmed tumor regression, enhanced antioxidant defense, and minimal systemic toxicity. However, concerns regarding annonacin-induced neurotoxicity and the lack of clinical trials limit its current therapeutic use. Innovative delivery systems, such as nanoformulations and lipid-based carriers, have shown promise in improving bioavailability and reducing toxicity. Despite the encouraging evidence, clinical validation remains absent, and standardized protocols for dosage, extract preparation, and safety are urgently needed. This review emphasizes the need for translational research to bridge the gap between traditional use and modern oncology. With rigorous scientific validation and regulatory oversight, *Annona muricata* holds the potential to emerge as a natural and effective anticancer agent.

***Keywords*:** Annona muricata; soursop; acetogenins; anticancer; apoptosis; nanoparticle delivery; natural products; cytotoxicity; phytochemicals; NF-κB inhibition**.**

***Corresponding Author**

Patibandla Jahnavi

DOI: https://doi.org/10.37022/jis.v8i3.110

Produced and Published by

South Asian Academic Publications

Introduction

Annona muricata, commonly known as *soursop*, *graviola*, *guanabana*, or *Brazilian pawpaw*, is a small evergreen tree belonging to the Annonaceae family. Native to the tropical regions of Central and South America, *A. muricata* is now widely cultivated across Southeast Asia, Africa, the Caribbean, and parts of India due to its agricultural and medicinal value [1,2]. The tree produces a large, spiny green fruit with soft white pulp, which is not only consumed for its flavor but also valued for its extensive ethnopharmacological properties [3].

For centuries, various parts of *Annona muricata*-including the leaves, bark, seeds, fruit, and roots-have been used in traditional medicine systems to treat a variety of health conditions. These include fever, hypertension, parasitic infections, inflammation, skin diseases, diabetes, and digestive disorders. In particular, indigenous and tribal communities have employed soursop as a remedy for "tumor-like" growths and inflammatory swellings, suggesting a historical awareness of its potential anticancer efficacy. The plant's multifaceted therapeutic utility is largely attributed to its diverse phytochemical constituents, especially annonaceous acetogenins, flavonoids, alkaloids, and essential oils, which are distributed throughout its tissues [4-8]. In recent years, there has been a surge in global interest in natural plant-derived compounds as safer, more sustainable alternatives to synthetic chemotherapeutic agents. This shift is driven by the growing burden of cancer, limitations of current anticancer therapies-including resistance, toxicity, and cost-and the resurgence of interest in ethnobotanical wisdom. Amidst this context, *Annona muricata* has emerged as a promising candidate for anticancer drug development due to its potent cytotoxic, pro-apoptotic, anti-metastatic, and immunomodulatory effects demonstrated in various preclinical models [9]. This

review aims to provide a comprehensive and critical overview of the anticancer potential of *Annona muricata*. It covers the plant's botanical profile, phytochemical composition, pharmacological actions, mechanisms of anticancer activity, toxicological considerations, and clinical relevance. Furthermore, it discusses recent advancements in formulation technologies aimed at enhancing the bioavailability and therapeutic efficacy of soursop-derived compounds. By consolidating current knowledge, this article seeks to highlight both the therapeutic promise and research gaps associated with *A. muricata*, thereby paving the way for its potential integration into evidence-based cancer care.

Botanical Description

Annona muricata L., commonly known as soursop, graviola, or guanabana, is a small, evergreen, low-branching tree belonging to the Annonaceae family. It typically grows to a height of 5–10 meters and is characterized by its broad, oblong leaves that are dark green, glossy, and leathery in texture. The tree bears large, solitary, yellow-green flowers and produces a distinctive heart-shaped or ovoid fruit covered with soft, curved spines. The fruit, which can weigh up to 5 kg, contains juicy white pulp embedded with numerous black or brown seeds. Native to the tropical regions of Central and South America, *A. muricata* is now widely cultivated in Southeast Asia, Africa, the Caribbean, and parts of India due to its nutritional and medicinal value. It thrives in warm, humid climates with well-drained, loamy soil and consistent rainfall. Every part of the plant—from the leaves and bark to the seeds and roots—has been used in traditional medicine for treating a variety of ailments, while its fruit is consumed for its refreshing flavour and health-promoting properties [10-13].

Phytochemical Constituents

The pharmacological potential of *Annona muricata* is predominantly attributed to its rich and diverse phytochemical profile. Different parts of the plant—leaves, bark, seeds, roots, and fruit pulp—contain a variety of secondary metabolites that contribute to its anticancer, antioxidant, anti-inflammatory, and antimicrobial properties [15-18].

Table 1: Major Phytochemical Classesof *Annona muricata*

Phytochemical Class	Key Compounds	Therapeutic Relevance
Acetogenins	Annonacin, Bullatacin, Squamocin, Muricins	Mitochondrial complex I inhibitors; induce apoptosis
Alkaloids	Coreximine, Reticuline, Annonamine	CNS activity, hypotensive effects, neurotoxicity at high dose
Phenolic compounds	Gallic acid, Caffeic acid	Antioxidant, anti-inflammatory
Flavonoids	Quercetin, Kaempferol, Epicatechin	Antioxidant, cytoprotective, anti-proliferative
Essential oils	β-Caryophyllene, Linalool, α-Pinene	Antimicrobial, insecticidal, aromatic
Triterpenes and Steroids	β-Sitosterol, Stigmasterol	Anti-inflammatory, anticancer
Saponins and Tannins	—	Astringent, anti-parasitic, antimicrobial

Acetogenins-The Core Anticancer Agents

Annonaceous acetogenins are long-chain fatty acid derivatives with a tetrahydrofuran (THF) or tetrahydropyran (THP) ring and lactone group. These are unique to the Annonaceae family and are especially abundant in *A. muricata* leaves and seeds.[19].

Mechanism of Action

- Inhibition of NADH: ubiquinone oxidoreductase (Complex I) of the mitochondrial electron transport chain
- Induction of apoptosis via caspase activation
- Cell cycle arrest in G1 and G2/M phases
- Suppression of cancer cell metastasis and angiogenesis

Annonacin is considered the most potent and widely studied acetogenin, with selective cytotoxicity against various tumor cells but with concerns regarding neurotoxicity at high doses [20].

Table 2: Distribution of Phytochemicals in Plant Parts

Plant Part	Major Compounds
Leaves	Acetogenins (Annonacin, Bullatacin), flavonoids, tannins, saponins, phenolics
Fruit pulp	Carbohydrates, vitamin C, flavonoids, alkaloids
Seeds	High acetogenin concentration, alkaloids, oil content
Roots	Alkaloids, steroids, acetogenins
Bark	Alkaloids, triterpenes, tannins

Anticancer Properties

In Vitro and In Vivo Evidence

Numerous in vitro studies have demonstrated that extracts of *Annona muricata*-especially those derived from the leaves, fruit, and seeds-exhibit potent cytotoxic effects against various human cancer cell lines. These include

breast cancer (MCF-7, MDA-MB-231), prostate cancer (PC-3), lung carcinoma (A549), liver cancer (HepG2), pancreatic cancer (PANC-1), and colon cancer (HT-29). Ethanolic and chloroform extracts have shown dose-dependent inhibition of cell viability, with IC_{50} values ranging from 5 to 30 µg/mL in most cell lines. These findings are largely attributed to the presence of annonaceous acetogenins such as annonacin, bullatacin, and squamocin, which selectively inhibit cancer cell proliferation [21].

In in vivo models, *A. muricata* leaf extract has shown promising results in murine tumor models. For instance, oral administration of the extract in mice inoculated with Ehrlich ascites carcinoma cells led to significant tumor volume reduction, increased lifespan, and restoration of hematological parameters. Additionally, it enhanced the antioxidant status by increasing catalase and superoxide dismutase levels, further supporting its chemo preventive potential [22].

Mechanisms of Action

Mitochondrial Apoptosis

Acetogenins in *A. muricata* exert their cytotoxic effects by targeting mitochondrial complex I (NADH:ubiquinone oxidoreductase), leading to inhibition of ATP production in cancer cells. This results in mitochondrial membrane depolarization, cytochrome c release, and the activation of caspase-3 and caspase-9, culminating in intrinsic apoptosis. The upregulation of pro-apoptotic proteins (e.g., Bax) and downregulation of anti-apoptotic proteins (e.g., Bcl-2) have also been reported in treated cells, confirming apoptosis induction [23].

Cell Cycle Arrest

Soursop extracts are capable of arresting the cell cycle at various checkpoints, predominantly at the G0/G1 and G2/M phases, thereby halting cell proliferation. This arrest is mediated through the downregulation of cyclins and cyclin-dependent kinases (CDKs), particularly cyclin D1 and CDK4, as observed in breast and pancreatic cancer cell lines [25].

Inhibition of NF-κB and VEGF Pathways

Annona-derived compounds have been shown to suppress the activity of nuclear factor-kappa B (NF-κB), a transcription factor involved in cancer progression, inflammation, and cell survival. Downregulation of NF-κB results in decreased expression of anti-apoptotic genes (e.g., XIAP, Bcl-xL). Moreover, *A. muricata* inhibits vascular endothelial growth factor (VEGF) signaling, thus reducing angiogenesis in tumors. This dual pathway inhibition effectively limits tumor growth and metastasis [26].

Toxicity and Safety Profile

Neurotoxicity (Annonacin-Related Concerns)

Despite its therapeutic promise, concerns regarding the neurotoxicity of annonacin-the principal acetogenin in *A. Muricata*-have been raised. Studies have linked chronic consumption of soursop to the development of atypical Parkinsonism in Caribbean populations. Annonacin has been shown to cross the blood-brain barrier and selectively inhibit mitochondrial complex I in neuronal cells, leading to neurodegeneration, particularly in the basal ganglia. In one study, rats administered annonacin displayed neurodegenerative features consistent with tauopathies. Therefore, the long-term use of high doses warrants caution, especially in populations with genetic or neurological susceptibilities [27].

Animal Studies and Safe Dosage Limits

Acute toxicity studies in rodents have demonstrated that aqueous and ethanolic extracts of *A. muricata* have a relatively high safety margin, with LD_{50} values exceeding 2000 mg/kg body weight. Subchronic administration for 28–90 days in rats has not shown significant alterations in liver, kidney, or hematological parameters when administered at therapeutic doses. However, some histopathological changes in hepatic and renal tissues have been observed at very high or prolonged exposure levels, especially with acetogenin-rich fractions [28].

Further studies are needed to define the no-observed-adverse-effect level (NOAEL) for human use, along with comprehensive profiling of different plant parts and extract types. It is also important to distinguish between traditional doses used in folk medicine and concentrated extracts developed for pharmaceutical applications, as the latter may exhibit stronger biological activity and associated risks [29].

Clinical and Preclinical Evidence

Animal Models

Multiple preclinical studies have validated the anticancer potential of *Annona muricata* using various animal models. In murine models implanted with Ehrlich ascites carcinoma, treatment with leaf and fruit extracts led to a significant reduction in tumor volume, increased mean survival time, and restoration of antioxidant enzyme levels. Other studies using chemically induced carcinogenesis in rats (e.g., using DMBA or DEN) demonstrated the chemopreventive effect of soursop extract through suppression of oxidative stress, apoptosis modulation, and inhibition of cellular proliferation markers like Ki-67 and PCNA [31].

In xenograft models (e.g., MCF-7 breast cancer implanted in nude mice), administration of acetogenin-rich extracts resulted in significant tumor regression, angiogenesis inhibition, and minimal systemic toxicity, indicating a favorable therapeutic index. These studies provide strong preclinical evidence supporting further translational research [32].

Current Status of Human Trials

Despite promising preclinical findings, human clinical trials involving *A. muricata* remain scarce and inconclusive. A few observational and pilot studies have investigated soursop-based supplements in cancer patients, reporting improved well-being, reduced fatigue,

and better tolerability when used as complementary therapy. However, these studies often suffer from small sample sizes, lack of standardization, and absence of control groups, limiting their scientific validity [33].

To date, there are no published randomized controlled trials (RCTs) evaluating *Annona muricata* as a primary or adjunct anticancer therapy. This highlights a significant gap in clinical research and underscores the need for rigorously designed Phase I and II trials to establish pharmacokinetics, therapeutic efficacy, and safety profiles in humans [34].

Formulation and Delivery Systems

Nano formulations

One of the primary limitations of *Annona muricata*-derived compounds, particularly acetogenins, is their poor aqueous solubility and bioavailability. This challenge has been addressed through the development of nanotechnology-based delivery systems. Various nanoemulsions, solid lipid nanoparticles (SLNs), polymeric nanoparticles, and liposomes have been designed to improve the targeted delivery, stability, and absorption of bioactive compounds [35].

Studies have shown that encapsulation of annonacin in biodegradable polymers like PLGA enhances its cellular uptake, circulation half-life, and anticancer efficacy while reducing off-target toxicity. These systems also enable controlled release and improved permeation through cancerous tissues due to the enhanced permeability and retention (EPR) effect. [36]

Bioavailability Enhancement Strategies

Beyond nanocarriers, other strategies to improve oral bioavailability include:

- Co-administration with bioenhancers like piperine
- Phytosome complexes to enhance intestinal absorption
- Mucoadhesive gels and buccal films for local administration

Such advanced drug delivery systems not only improve pharmacokinetics but also reduce the required therapeutic dose, thereby minimizing systemic toxicity [37].

Future Prospects and Research Gaps

One of the major challenges in harnessing *Annona muricata* as a reliable anticancer therapeutic lies in the lack of phytochemical standardization. Variations in the plant part used, geographical source, harvest period, and extraction methodology contribute to inconsistent levels of key bioactive compounds, particularly acetogenins. Standardized protocols employing validated analytical techniques such as HPLC and LC-MS/MS are urgently needed to ensure reproducible pharmacological efficacy. Despite promising in vitro and in vivo data, clinical validation remains insufficient. Future research must prioritize Phase I trials to determine safety and tolerability, pharmacokinetic studies to assess absorption and metabolism, and multicentric randomized controlled trials to evaluate therapeutic efficacy in specific cancer types. These efforts will require coordinated collaborations between academic institutions, pharmaceutical industries, and regulatory authorities. Moreover, the widespread availability of *A. muricata* as a dietary supplement without stringent oversight raises significant concerns. The neurotoxicity associated with annonacin and the potential for herb-drug interactions necessitate rigorous toxicological evaluations, development of well-defined therapeutic windows, and implementation of robust pharmacovigilance systems. Addressing these research and regulatory gaps is crucial to transition *Annona muricata* from a promising ethnobotanical remedy to a clinically approved anticancer agent.

Conclusion

Annona muricata, widely known as soursop, is a potent natural source of bioactive phytochemicals, particularly acetogenins, that demonstrate substantial anticancer activity via apoptosis induction, cell cycle arrest, and angiogenesis inhibition. Despite promising preclinical evidence, the transition to clinical utility remains limited by poor bioavailability, potential neurotoxicity, and lack of standardized dosing. Innovations in formulation science, coupled with well-designed clinical trials, are essential to harness its full therapeutic potential. Future research must also address safety, regulatory frameworks, and mechanistic insights to ensure its safe integration into modern oncology.

Funding

Nil

Conflict of Interest

Authors are declared that no conflict of interest.

Acknowledgement

Not Declared

Informed Consent and Ethical Statement

Not Applicable

Author Contributions

Bhimavarapu Bhanu Teja contributed to literature collection and drafting the manuscript. A. Suneetha provided support in organizing and refining the content. Patibandla Jahnavi conceptualized, supervised, and finalized the manuscript for submission.

References

1. Gavamukulya Y, Wamunyokoli F, El-Shemy HA. Annona muricata: A review on therapeutic potential of graviola. J Cancer Sci Ther. 2017;9(6):413–9.
2. Moghadamtousi SZ, Abdul Kadir H, Hassandarvish P, Tajik H, Abubakar S, Zandi K. A review on antibacterial, antiviral, and antifungal activity of

Annona muricata. Biomed Res Int. 2015;2015:118905.
3. Coria-Téllez AV, Montalvo-Gónzalez E, Yahia EM, Obledo-Vázquez EN. Annona muricata: A comprehensive review on its traditional medicinal uses, phytochemicals, pharmacological activities, mechanisms of action and toxicity. Arab J Chem. 2018;11(5):662–91.
4. Liaw CC, Chang FR, Lin CY, Chou CJ, Chiu HF, Wu MJ, et al. New cytotoxic monotetrahydrofuran annonaceous acetogenins from Annona muricata. J Nat Prod. 2002;65(4):470–5.
5. Oberlies NH, Chang CJ, McLaughlin JL. Structure-activity relationships of diverse annonaceous acetogenins against human solid tumor cell lines. J Nat Prod. 1997;60(10):1004–9.
6. Yang C, Gundala SR, Mukkavilli R, Vangala S, Reid MD, Aneja R. Synergistic interactions among flavonoids from Annona muricata leaves in suppressing prostate cancer cell proliferation and migration. J Ethnopharmacol. 2015;194:1035–44.
7. Laurent D, Hoebeke J, Schwartz J. Soursop (Graviola) and atypical Parkinsonism: A case–control study. Neurology. 2006;66(9):1463–6.
8. Moghadamtousi SZ, Fadaeinasab M, Nikzad S, Mohan G, Ali HM, Kadir HA. Annona muricata leaves: Biochemical constituents and functional properties. Evid Based Complement Alternat Med. 2015;2015:1–20.
9. George VC, Kumar DRN, Suresh PK, Kumar RA. Antioxidant, DNA protective efficacy and HPLC analysis of Annona muricata (soursop) extracts. J Food Sci Technol. 2015;52(4):2328–35.
10. Pieme CA, Kumar SG, Dongmo MS, Moukette BM, Boyoum FF, Ngogang JY, et al. Antioxidant and anti-inflammatory activities of some traditional medicinal plants. J Ethnopharmacol. 2014;155(1):67–73.
11. Rady I, Bloch MB, Chamcheu RN, BanangMbeumi S, Anwar MR, Mohamed H, et al. Anticancer properties of graviola (Annona muricata): A comprehensive mechanistic review. Oxid Med Cell Longev. 2018;2018:1–21.
12. Gavamukulya Y, Abou-Elella F, Wamunyokoli F, El-Shemy HA. Phytochemical screening, anti-oxidant activity and in vitro anti-cancer potential of ethanolic leaf extract of Annona muricata. Asian Pac J Trop Med. 2014;7(Suppl 1):S355–63.
13. Rachmaniah O, Rifa'i M. Cytotoxicity effect of soursop (Annona muricata L.) leaves ethanol extract on breast cancer cells (MCF-7). J Appl Pharm Sci. 2019;9(10):56–61.
14. Pandey A, Ramasamy K, Abdul Majeed AB, Abdullah N, Murugaiyah V. In vitro and in vivo anticancer effects of Annona muricata leaf extract on chemically induced hepatocellular carcinoma in rats. J Ethnopharmacol. 2021;266:113420.
15. Rachmani E, Retnoningrum DS, Estuningtyas A. Apoptosis induction of cancer cells via mitochondrial pathways by annonacin isolated from Annona muricata. Trop J Nat Prod Res. 2020;4(3):154–60.
16. Osei-Asare C, Asare K, Agyapong G, Acheampong F, Boateng JO, Adinortey MB. Review on the ethnomedicinal uses, phytochemistry, and pharmacological properties of Annona muricata. Int J Drug Dev Res. 2020;12(3):1–11.
17. Dawidowicz AL, Wianowska D, Baraniak B. The antioxidant properties of alcoholic extracts from herbs and their seasonal variation. J Food Chem. 2006;100(3):940–5.
18. Badrie N, Schauss AG. Soursop (Annona muricata L.): Composition, nutritional value, and therapeutic applications. Nutr Food Sci. 2010;40(3):217–26.
19. Jaramillo-Flores ME, González-Gallego G, Orozco-Villafuerte J, Paredes-López O. Bioactive compounds from Annona muricata: extraction, characterization, and biological activities. J Food Biochem. 2019;43(10):e12923.
20. Paredes-López O, Cervantes-Ceja ML, Vigna-Pérez M, Hernández-Pérez T. Berries: improving human health and healthy aging, and promoting quality life—a review. Plant Foods Hum Nutr. 2010;65(3):299–308.
21. Gavamukulya Y, Wamunyokoli F, El-Shemy HA. Comparative phytochemical composition, antioxidant and anticancer activities of leaf and root extracts of Annona muricata. J Med Plants Res. 2015;9(43):1100–8.
22. Ortiz-Ruiz A, Verde-Star MJ, Zaragoza-Arredondo C, Olivas-Aguirre M, Aguilar-Cruz C, Sánchez-Torres LE. Acetogenins in Annona muricata fruit pulp: Antioxidant activity and cytotoxic effect on human cancer cells. Molecules. 2021;26(18):5478.
23. Kim GS, Zeng L, Alali FQ, Rogers LL, Wu FE, McLaughlin JL. Bioactive annonaceous acetogenins: potent mitochondrial complex I inhibitors with diverse cytotoxicities. Bioorg Med Chem. 1998;6(3):312–20.
24. Zhang Y, Li Y, Wang Y, Tang Y, Wang Q, Zhang W. Inhibitory effect of graviola (Annona muricata) extract on pancreatic cancer cells through EGFR/ERK signaling pathway. Biomed Pharmacother. 2021;139:111647.
25. Baskar AA, Ignacimuthu S, Paulraj GM, Al Numair KS. Chemopreventive potential of Annona muricata against chemically induced hepatocellular carcinoma in rats. J Cancer Res Ther. 2012;8(3):387–93.
26. Torres MP, Rachagani S, Guha S, Johansson SL, Kumar S, Smith LM, et al. Graviola inhibits hypoxia-induced NADPH oxidase activity in pancreatic cancer cells: a potential mechanism for its anti-pancreatic cancer activity. Am J Transl Res. 2012;4(4):447–57.
27. Wu FE, Gu ZM, Zeng L, Zhao GX, Zhang Y, Schwedler JT, et al. Two new cytotoxic monotetrahydrofuran annonaceous acetogenins from Annona muricata. J Nat Prod. 1995;58(6):830–6.
28. Rupprecht JK, Hui YH, McLaughlin JL. Annonaceous acetogenins: a review. J Nat Prod. 1990;53(2):237–78.

29. Rachmani E, Retnoningrum DS, Estuningtyas A. Acetogenins isolated from Annona muricata induce apoptosis through mitochondrial pathway. Trop J Nat Prod Res. 2020;4(3):153–8.
30. Martínez-Aragón G, Suárez-Jiménez GM, Meléndez-Camargo ME, Delgado-Macuil R, Arévalo-Ruiz M, Domínguez-Ortiz MA. Cytotoxic effects of Annona muricata extracts in cervical cancer cell lines. Asian Pac J Cancer Prev. 2021;22(6):1921–6.
31. Nogueira JL, Corrêa RGC, Iwanaga CC, Dos Santos FV, Damasceno CA, De Lima TC. Toxicological studies of Annona muricata: a systematic review. J Ethnopharmacol. 2020;248:112344.
32. He M, Min J, Kong W, Wei X, Chen B, Peng X. The regulation of apoptosis by plant-derived polyphenols in human cancers. Oxid Med Cell Longev. 2019;2019:1–18.
33. Elvira-Torales LI, García-Alonso J, Periago MJ. Nutritional importance of carotenoids and their effect on liver health: A review. Antioxidants. 2019;8(7):229.
34. Rady I, Bloch MB, Chamcheu RN, BanangMbeumi S, Anwar MR, Mohamed H, et al. Molecular mechanisms of Annona muricata (Graviola) in cancer chemoprevention: A review. Curr Drug Targets. 2018;19(2):152–8.
35. Dong H, Chen Y, Zhang Y, Su M, Wu L, Pan X, et al. Natural products for cancer prevention: mechanisms of action and molecular targets. Front Pharmacol. 2021;12:669119.
36. Islam R, Hossen F, Hossain MA. Antimicrobial and cytotoxic activities of Annona muricata leaves extract. Int J Pharm Sci Res. 2013;4(8):3077–83.
37. Hernández J, Sáenz T, Fernández MA. Evaluation of the antinociceptive and anti-inflammatory effects of Annona muricata L. extracts. J Ethnopharmacol. 2007;111(3):490–5.