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Essential oil isolates of Indian Black Berry Leaves: A Review

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Abstract

Essential oils are the concentrated fluids of complex blends of the volatile compounds which can be separated from a few plants organs and they are excellent source of a few bioactive mixes. Jamun is a very commom aromatic plant which is found in many places. Janum (*Syzygium cumini)* have some properties like antioxidative and antimicrobial etc. Essential oils from jamun can be extracted by various ways but hydrodistillation is considered as the best technique because a good yield can be obtained by this method. *Syzygium cumini* contains appreciable amounts of polyphenols, ellagic acid, and ellagitannins, in addition to an abundance and diversity of anthocyanins. It is also discuss that it has cancer chemopreventive potential of its bioactive constituents. Because of their antioxidant properties the leaf essential oil from Indian black berry may be used as natural preservative element in the food and some other industries like pharmaceutical industries.

Key words: Essential oil, Jumun, Biological activities, Nanoparticles, Steam distillation

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1. Introduction

Aromatic plants and their oils have been examined for their effectiveness for food safety and conservations applications [1] furthermore, they have got consideration as development and health promoter [2]. In the many plants essential are naturally occurring antimicrobials [3-4] found that have been shown in a large number of uses by decreasing growth and also survival of the some microorganisms [5]. These antimicrobials have been studied for their broad histories of their utilization in the foods and from various components of the plants they can be identified like leaves, barks, fruits flowers, roots and stems [6-8]. Essential oils are not actually the pure oils, but they are lightly soluble in water as are oils typically, essential oil considered highly complex mixtures of frequently hundreds of separate aroma compounds [9]. There are various methods exist for the extraction of essential oils, their names are mechanical expression, maceration, steam distillation, effleurage, water distillation, water and steam distillation [10]. Hydrodistillation is known as the most used technique for the extraction of essential because specific characters of plant material protected by this method. Essential oils extracted from plant in a oxygenated derivatives, complex mixture of terpenes and also other aromatic compounds [11]. Essential oils are prepared by elements carbon, oxygen and hydrogen. Their most common class is terpens. The structure of terpenes can be reorganized as the joining together of identical branched units each of which comprises of five carbon atoms. Most of the essential oils are only less soluble in water, They have characteristic odor and are flammable [12]. In foods many speices and herbs usually used to provided most of the essential oils that have been studied because of their antimicrobial activity [13] Composition is depend on the part of the plant which is used for extraction of oil such as green parts the leaves and the other part of the plant, wood pericarp or seed, or may be roots [14].

The *Syzygium cumini* (Jamun) fruit has been studied for many beneficial properties such as digestive, hypoglycemic effects, liver stimulation and coolant. The leaves of Indian black berry have essential oils with a very pleasant odor. Essential oil of Indian black berry leaves comprises dipentenes terpenes, sesquiterpenes, isoquercitin, myricetin and the kaempferol in the different concentration. Its leaves are very useful in the treatment of diabetes, fever, constipation, gastropathy, dermopathy and strangury. It is studied that jamun is not effective in the treatment of type II diabetes so it is not utilized to cure type II diabetes It has been reported that *Syzgium cumini* species possess antibacterial activity. It has been also shown that aqueous and methanol extract *Syzgium* species stop the growth of the various fungal microorganism that involved in skin diseases [15]. According to the traditional systems of the medicine Jamun can work as an excellent blood purifier. To keep the

body healthy jamun is a good general tonic. When the day is hot and sultry the fruit also has a cooling effect. The fruit is a small, sour, rough, sweet, acidic, destroys in digestion, antiacidic, and coolant used for the treatment in skin diseases. As janum is very effective in diabetes, indigestion, dysentery, gastrointestinal problems, and also usefull for weight loss, that's why leaves of *Syzygium cumini* are utilized in the traditional medicine. Although numerous *S. cumini* leaves oils have been widely studied, including their chemical composition and other biological importance [16]. There are various names are Jambul, Indian Blackberry, Black Plum, Black Plum, Jamblang, Java Plum, and Jamun. The fruits of Jamun plant ripe one time in a year. The fruits are commonly used for fitness drinks, squashes, jellies, making jams and wine. Various other parts of the Jamun plant have also been reported for their antioxidant, neuropsycho-phar -macological, anti-HIV, anti-microbial, nitric oxide scavenging, anti-bacterial, an-tileishmanial and antifugal, free radical scavenging, anorexigenic, radioprotective and anti-ulcerogenic anti-diarrheal, antifertility, gastroprotective, activities [17].

Indian Java plum or black plum is an edible tropical fruit produced from the trees of *Syzygium cumini*. The fruits take the shape of square berries, with deep purple or may be bluish color and pink pulp, with different medicinal uses such as Ayurveda as an the astringent, as antiscorbutic, stomachic, antidiabetic, enlargement of spleen, and in chronic diarrhea. The history of fruit concentrate of *Syzygium cumini* is prolonged due to its use in different medicinal aspects and now, has huge market for the treatment of chronic diarrhea and various other enteric disorders, such as its use as an antimicrobial [18]. The leaves of *Syzygium cumini* are commonly used to decrease debates [19].

2. Chemical composition

Essential oils are the complex natural compounds which have about to 20–60 different components at variable concentrations. However chemical composition varies with different seasons [9]. These chemical mixtures are categorized by two or three major constituents at very high concentrations of the 20–70%, in the comparison to others constituents that are present in the trace quantities [20]. It was reported that by hydrodistillation of the *Syzigium cumini* leaves gives a pale essential oil with a good yield of 0.52%. GC-FID and GC/MS analyses are used to characterize the volatile oil constituents [3-21-22]. Eleven compounds constituting 99.98% of the total oil, were recognized [23]. Oxygenated monoterpenes and monoterpene hydrocarbons establish the main part of the oil, whereas sesquiterpene hydrocarbons have a lesser fraction and oxygenated sesquiterpenes were failed to be detected in the oil. (E)-bocimene (11.71%), (Z)-β-ocimene (28.98%) and α-Pinene (31.85%), were the major constituents present in the essential oil. Prior chemical classifications of essential oils isolated from stems, fruits and leaves of *S. cumini* have very common chemical profiles than the one found in this study. The presence of isomers of ocimene and α-pinene among the major essential-oil constituents has been observed in numerous studies [24]. The oil composition variability can be due to the genetic, environmental and physiological factors [25]. Chemical composition of the essential oils is affected by many factors, like geographic and climatic conditions, method of distilling the plant, day time of collection, harvest period, vegetative stages of the plant and existence of chemotypes [26].

3. Extraction technique

3.1. Solvent extraction

Solvent extraction is a technique which is used for the extraction of essential oils it is also called as the liquid–liquid extraction. As it is a method to isolate a compound based on the solubility of its constituents. The process is done by utilizing two liquors that they do not mix, such as, an organic solvent and water. Solvent extraction is usually utilized in the processing of the vegetable oil, perfumes as well as biodiesel. It is used on delicate plants to obtain higher quantities of essential oils at a cheaper cost. it can be applied sample preparation procedure in plant material analysis. It was reported that a good yield of jamun essential oil was obtained by solvent extraction. But it is costly technique.

3.2. Hydrodistillation

It is a classical process used usually used for the large scale extraction like industrial extraction of essential oils. Conventionally, the raw plant material is fed into a distillation apparatus heated water and essential oil are carried out with the flow as the steam passes through the plant material, breaking down the leaf constituents. After extraction, essential oil is redistilled, to get more pure product. Hydrodistillation is time consuming procedure that produces low yields. Over the past few years, many different solvents and heating sources are being used to improve yield and quality and shorten extraction times. It was reported that by hydrodistillation of the leaves of *Syzygium cumini* provided colorless essential oil with a yield of 0.52%. Essential oils which are lighter than water will float on the surface.

3.3. Steam Distillation

Steam refining is the way toward refining plant material with steam delivered outside the still through a steam generator. It is generally referred to as a boiler. As in water and steam refining, the plant material is put on a perforated grid over the steam inlet. Satellite steam generation is advantageous due to the amount of steam can be readily controlled. A very large amount of oil can be obtained by using steam distillation it means that it is used in large scale production. A major drawback to the steam distillation is the much higher costs used to construct such a

facility [27].

3.4. Vacuum Distillation

Vacuum distillation is a process ustilized to isolated higher boiling divisions of crude oil. It occurs at reduced pressures, thus by decreasing the boiling point of a material. Hence, as high boiling constituents are boiled at low temperatures, without the risk of cracking. Usually, the pressure used in vacuum distillation is set in the ranging from 50 to 100 mmHg. The lubricating oil stocks may needs even low pressure and other operating conditions. This process is used for the vacuum distillation of a different of high-boiling organic compounds with various columns. Decomposition in the distilling pot is reduced and pressure readings have been constant for different fraction changes. It was reported that by hydrodistillation of the leaves of *Syzygium cumini* provided colorless essential oil with a yield of 0.52%. Essential oils which are lighter than water will float on the surface.

4. Nanoparticles

Nanotechnology is the creation and utilization of materials with the components that exsist at the nanoscale; and they are up to 100 nm in size. Nanoparticles are used in the different purposes, they are used in medical treatments, they play a vital role in the production of industry like in energy storage for solar and oxide fuel batteries, they are also very useful in the different materials of daily use such as, optical devices, sensor technology, catalytic, cosmetics or clothes electronic bactericidal and biological classification and also in the treatment of the cancers. They have high thermal conductivity and antibacterial activity. Metallic nanoparticles have numerous applications in different industries namely as Silver, Alloy, magnetic, Gold etc. there are two type of nanoparticals made by janum leaves essential oils their names are MgO and BaO. Both are very useful in many fields as nanoparticals.

5. Biological activities

5.1. Antioxidant effect

An antioxidant, is a system that may defined as a substance which is when present at lower concentrations associated with those of an oxidizable substrate, for the purpose of delays or may be prevents oxidation of the substrate [28]. The use of natural antioxidants, such as ascorbic acid, phenolic compounds including flavonoids, to copherols and volatile compounds for preventing oxidation of biomolecules which can cause cell injury and death as well [29]. Antioxidants are important as they play an important role in biological systems by destroying the formation of reactive oxygen species by reducing hydroperoxides (ROO•) and H_2O_2 and scavenging free radicals [30]. But, many studies have shown conclusively that the major % of the antioxidant activity is due to compounds such as flavonoids, isoflavones, flavones, and anthocyanins rather than the conventionally considered vitamins C, E, and carotene. There is a direct relationship between polyphenolic content of plant extracts and antioxidant activity. The seeds of *S. cumini* are wealthy in flavonoids, which record for the have high complete phenolic content with antioxidant activity and scavenging of free radicals and a defensive impact on antioxidant enzymes [31].

5.2. Antibacterial activity

It is reported that essential oils of *S. cumini* leaves have been possess antibacterial activity against two types of bacteria. Their names are Gram positive and Gram negative bacteria. Between the verified extracts, a maximum inhibition zones methanol extract has showed of 18– 24 mm against the tested bacteria. Both the essential oils and methylene chloride extract reported moderate inhibition zones of 13–16 and 12–14 mm. Antimicrobial properties of the essential oil of *Syzigium cumini* is due to the reason that essential oils may disturb the permeability of cellular membranes [32].

5.3. Antineoplastic Effects

In the cancer treatment of cancer Chemotherapy has been important for more than five decades and when metastasis has ensued it is an obligatory treatment modality. These are depending on the patient compliance and clinical stage, chemotherapy is used in both ways in combination surgery and it can also be used alone [33]. Studies suggest that 47% antineoplastic drugsused from the natural sources. In vitro studies it has shown that cytotoxic effects present in whole Jamun essential oils. That effects on the human cancer cells, SiHa HPV-16 positive and the HeLa HPV-18 positive. The extract caused a concentration dependent cell death with the effect being more prominent in the HeLa than SiHa cells. In both the cell lines the basic extract was saw to be superior than the methanolic extract [34].

5.4. Jamun Extracts Inhibit Oxidative DNA Damage

It have been shown that Jamun polyphenolics work as potential antioxidants as discussed earlier by different mechanisms, including reactive nitrogen species, and direct scavenging of free radicals, and reactive oxygen species that include hydroxyl and peroxyl radicals. The potentials of jamun (pulp) aqueous and organic extracts were evaluated for their efficacy to inhibit 4-OHE_2/Cu_2^+ made oxidative DNA adducts generated in this system. Although the data for the interaction of anthocyanins and anthocyanidins is small in regard to direct interaction with DNA, by covalent binding one of the jamun's active constituents, EA, has been shown to defend DNA from oxidative destruction [35].

5.5. Molluscicidal and Leishmanicidal Activity of the Leaf Essential Oil

In Brazil the the essential oil were extracted from the leaves of indian blackberry were observed. There was different composition of oil were obtained. In the oil a very high amount of monoterpenes (87.12%) was found by using GC/MS Analyses there are other with the major components

being α-pinene (31.85%), and (E)-β-ocimene (11.71%) and (Z)-β-ocimene (28.98%). It was tested to evaluate the molluscicidal effect of the oil. The essential oil also showed significant activity against Leishmania Iamazonensis. Thus, the essential oil of *S. cumini* exposed specific activity as a leishmanicidal and molluscicidal agent and has capacity to be in fighting with ignored tropical diseases such as schistosomias and leishmaniasis.

6. Applications

In various traditional systems of medication Jaman is an important medicinal plant. As It is very useful and effective in the treatment of a large number of diseas like diabetes mellitus, inflammation, diarrhea and ulcers and preclinical from studies it have been also shown that jamun possess chemopreventive, antineoplastic and radio protective properties. For sherbet syrup and "squash" Jambolan juice is excellent. In India, there is a drink prepared by cooking the fruit for 5 to 10 minutes at the temperature 140˚F after making the juice, mixing it with sugar and water and adding citric acid and sodium benzoate as a preservative [36]. Customarily the jambul organic products, leaves, seeds, and bark are altogether utilized in ayurvedic medication *Syzygium cumini* is a common traditional medicinal plant, whose parts have been pharmacologically proven to possess antibacterial hypoglycemic, and anti-HIV activities [37]. The leaves, soaked in alcohol, are given in diabetes. In the treatment of dysentery the leaf juice is effective it may be alone or in mixture with some other juice like the juice of mango or emblic leaves. On skin diseases Jambolan leaves may be helpful as poultices. The phytochemicals like oxalic acid, malieic acid, gallic acid, cynidin glycoside, flavonoids, essential oils, friedelin that's have been reported for antianaemic, antidiarrhoeal, malieic acid, malieic acid, antipyretic, antibacterial, antineoplastic, anti-inflammatory, hypoglycemic, gastroprotective and hypolipidamic properties. Numerous studies have recommended that the extracts from different the parts of *Syzygium cumini* have many interesting biological activities [38] show antiinflammatory [39] anti-ulcerogenic, anti-allergic [40], antibacterial [38], antioxidant [41] antiplasmodic, and antitumor properties [16].

7. Summary

With strong aromatic components essential oils are plant-based volatile oils that are made up of different chemical compounds. Essential oil was isolated from the leaves of Indian black berry. Hydrodistillation is the technique which is mostly used for the extaction of indian black berry essential oils. Leaves of blackberry plant have been found effective in curing diarrhea and dysentery since early times they are also very effective in the treatment of dibeties but it is not usefull in type II dibeties. There there many studied reported on jamun oil. Search for alternatives that are effective, nontoxic, and cost-effective in prevention and treatment of cancer are of utmost importance. The anticancer potential of jamun is gaining considerable attention lately because of the presence of a multitude of bioactive phytochemicals, including anthocyanins and polyphenols.

References

[1] K. Fisher, C. Phillips. (2008). Potential antimicrobial uses of essential oils in food: is citrus the answer? Trends in food science & technology. 19(3): 156-164.

[2] A. Brenes, E. Roura. (2010). Essential oils in poultry nutrition: Main effects and modes of action. Animal Feed Science and Technology. 158(1-2): 1-14.

[3] M.A. Hanif, M.Y. Al-Maskari, A. Al-Maskari, A. Al-Shukaili, A.Y. Al-Maskari, J.N. Al-Sabahi. (2011). Essential oil composition, antimicrobial and antioxidant activities of unexplored Omani basil. Journal of Medicinal Plants Research. 5(5): 751-757.

[4] M.A. Hanif, H.N. Bhatti, M.S. Jamil, R.S. Anjum, A. Jamil, M.M. Khan. (2010). Antibacterial and antifungal activities of essential oils extracted from medicinal plants using CO2 supercritical fluid extraction technology. Asian journal of chemistry. 22(10): 7787.

[5] T.R. Callaway, J.A. Carroll, J.D. Arthington, T.S. Edrington, R.C. Anderson, S.C. Ricke, P. Crandall, C. Collier, D.J. Nisbet, Citrus products and their use against bacteria: potential health and cost benefits. In *Nutrients, Dietary Supplements, and Nutriceuticals*, Springer: 2011; pp 277-286.

[6] P. Erasto, G. Bojase-Moleta, R.R. Majinda. (2004). Antimicrobial and antioxidant flavonoids from the root wood of Bolusanthus speciosus. Phytochemistry. 65(7): 875-880.

[7] E.M. Abdallah, A.E. Khalid. (2012). A preliminary evaluation of the antibacterial effects of Commiphora molmol and Boswellia papyrifera oleo-gum resins vapor. International Journal of Chemical and Biochemical Sciences. 1: 1-15.

[8] A.A. Hamid, O.O. Aiyelaagbe. (2012). Pharmacological investigation of Asystasia calyciana for its antibacterial and antifungal properties. International Journal of Chemical and Biochemical Sciences. 1: 99-104.

[9] A.Y. Al-Maskri, M.A. Hanif, M.Y. Al-Maskari, A.S. Abraham, J.N. Al-sabahi, O. Al-Mantheri. (2011). Essential oil from Ocimum basilicum (Omani Basil): a desert crop. Natural product communications. 6(10): 1934578X1100601020.

[10] M.A. Hanif, S. Nisar, G.S. Khan, Z. Mushtaq, M. Zubair, Essential Oils. In *Essential Oil Research*, Springer: 2019; pp 3-17.

[11] P. Masango. (2005). Cleaner production of essential oils by steam distillation. Journal of Cleaner Production. 13(8): 833-839.

[12] B.T. Schaneberg, I.A. Khan. (2002). Comparison of extraction methods for marker compounds in the essential oil of lemon grass by GC. Journal of Agricultural and Food Chemistry. 50(6): 1345-1349.

[13] C. Cueva, M.V. Moreno-Arribas, P.J. Martín-Álvarez, G. Bills, M.F. Vicente, A. Basilio, C.L. Rivas, T. Requena, J.M. Rodríguez, B. Bartolomé. (2010). Antimicrobial activity of phenolic acids against commensal, probiotic and pathogenic bacteria. Research in microbiology. 161(5): 372-382.

[14] N.O. Olawore, I.A. Ogunwande, O. Ekundayo, K.A. Adeleke. (2005). Chemical composition of the leaf and fruit essential oils of Murraya paniculata (L.) Jack.(Syn. Murraya exotica Linn.). Flavour and fragrance journal. 20(1): 54-56.

[15] M. Chandrasekaran, V. Venkatesalu. (2004). Antibacterial and antifungal activity of Syzygium jambolanum seeds. Journal of ethnopharmacology. 91(1): 105-108.

[16] P. Shafi, M. Rosamma, K. Jamil, P. Reddy. (2002). Antibacterial activity of Syzygium cumini and Syzygium travancoricum leaf essential oils. fitoterapia. 73(5): 414-416.

[17] H. Sagrawat. (2006). Pharmacological potential of Eugenia jambolana: A review. Pharmacogn Mag. 2(6): 96-105.

[18] J. Lee, R.W. Durst, R.E. Wrolstad. (2005). Determination of total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants, and wines by the pH differential method: collaborative study. Journal of AOAC international. 88(5): 1269-1278.

[19] G.C. Jagetia, M.S. Baliga. (2002). Syzygium cumini (Jamun) reduces the radiation-induced DNA damage in the cultured human peripheral blood lymphocytes: a preliminary study. Toxicology letters. 132(1): 19-25.

[20] R. Croteau, T.M. Kutchan, N.G. Lewis. (2000). Natural products (secondary metabolites). Biochemistry and molecular biology of plants. 24: 1250-1319.

[21] M.A. Hanif, A.Y. Al-Maskri, Z.M.H. Al-Mahruqi, J.N. Al-Sabahi, A. Al-Azkawi, M.Y. Al-Maskari. (2011). Analytical evaluation of three wild growing Omani medicinal plants. Natural product communications. 6(10): 1934578X1100601010.

[22] I. Shahzadi, R. Nadeem, M.A. Hanif, S. Mumtaz, M.I. Jilani, S. Nisar. Chemistry and biosynthesis pathways of plant oleoresins: Important drug sources.

[23] R.P. Adams. (2007). Identification of essential oil components by gas chromatography/mass spectrometry. Allured publishing corporation Carol Stream, IL: pp.

[24] M.d.G.M.O. Henriques, E.C. Rosas, M.C.d. Souza, A.C. Siani, M.S. Ramos. (2013). Avaliação da atividade antiinflamatória dos óleos essenciais de cinco espécies de Myrtaceae. Revista Fitos. 2(02): 58-66.

[25] N. Sangwan, A. Farooqi, F. Shabih, R. Sangwan. (2001). Regulation of essential oil production in plants. Plant growth regulation. 34(1): 3-21.

[26] F. Sözmen, B. Uysal, E.O. Köse, Ö. Aktaş, I. Cinbilgel, B.S. Oksal. (2012). Extraction of the essential oil from endemic Origanum bilgeri PH Davis with two different methods: comparison of the oil composition and antibacterial activity. Chemistry & biodiversity. 9(7): 1356-1363.

[27] B. Kaufmann, P. Christen. (2002). Recent extraction techniques for natural products: microwave-assisted extraction and pressurised solvent extraction. Phytochemical Analysis: An International Journal of Plant Chemical and Biochemical Techniques. 13(2): 105-113.

[28] M.M. Khan, M. Iqbal, M.A. Hanif, M.S. Mahmood, S.A. Naqvi, M. Shahid, M.J. Jaskani. (2012). Antioxidant and antipathogenic activities of citrus peel oils. Journal of Essential Oil Bearing Plants. 15(6): 972-979.

[29] J.M. McCord. (2000). The evolution of free radicals and oxidative stress. The American journal of medicine. 108(8): 652-659.

[30] M. Naczk, F. Shahidi. (2006). Phenolics in cereals, fruits and vegetables: Occurrence, extraction and analysis. Journal of pharmaceutical and biomedical analysis. 41(5): 1523-1542.

[31] K. Šavikin, G. Zdunić, T. Janković, S. Tasić, N. Menković, T. Stević, B. Đorđević. (2009). Phenolic content and radical scavenging capacity of berries and related jams from certificated area in Serbia. Plant foods for human nutrition. 64(3): 212-217.

[32] A. Ultee, M. Bennik, R. Moezelaar. (2002). The phenolic hydroxyl group of carvacrol is essential for action against the food-borne pathogen Bacillus cereus. Appl. Environ. Microbiol. 68(4): 1561-1568.

[33] V.T. DeVita, S. Hellman, S.A. Rosenberg. (2011). Cancer: Principles and Practice of Oncology: Principles & Practice of Oncology. Wolters Kluwer/Lippincott Williams & Wilkins: pp.

[34] C.-T. Yeh, G.-C. Yen. (2005). Induction of apoptosis by the Anthocyanidins through regulation

of Bcl-2 gene and activation of c-Jun N-terminal kinase cascade in hepatoma cells. Journal of agricultural and food chemistry. 53(5): 1740-1749.

[35] H. Aiyer, M. Vadhanam, R. Stoyanova, G. Caprio, M. Clapper, R. Gupta. (2008). Dietary berries and ellagic acid prevent oxidative DNA damage and modulate expression of DNA repair genes. International journal of molecular sciences. 9(3): 327-341.

[36] E. Giovannucci, E.B. Rimm, Y. Liu, M.J. Stampfer, W.C. Willett. (2002). A prospective study of tomato products, lycopene, and prostate cancer risk. Journal of the National Cancer Institute. 94(5): 391-398.

[37] K. Ravi, K. Sivagnanam, S. Subramanian. (2004). Anti-diabetic activity of Eugenia jambolana seed kernels on streptozotocin-induced diabetic rats. Journal of medicinal food. 7(2): 187-191.

[38] C.N. Dias, K.A. Rodrigues, F.A. Carvalho, S.M. Carneiro, J.G. Maia, E.H. Andrade, D.F. Moraes. (2013). Molluscicidal and leishmanicidal activity of the leaf essential oil of Syzygium cumini (L.) SKEELS from Brazil. Chemistry & biodiversity. 10(6): 1133-1141.

[39] S. Muruganandan, K. Srinivasan, S. Chandra, S. Tandan, J. Lal, V. Raviprakash. (2001). Anti-inflammatory activity of Syzygium cumini bark. fitoterapia. 72(4): 369-375.

[40] F. Brito, L. Lima, M. Ramos, M. Nakamura, S. Cavalher-Machado, A. Siani, M. Henriques, A. Sampaio. (2007). Pharmacological study of anti-allergic activity of Syzygium cumini (L.) Skeels. Brazilian Journal of Medical and Biological Research. 40(1): 105-115.

[41] R. Kamal, S. Yadav, M. Mathur, P. Katariya. (2012). Antiradical efficiency of 20 selected medicinal plants. Natural product research. 26(11): 1054-1062.