**BIOACTIVE COMPOUNDS IN JAMUN (*Syzygium cumini* L.) ENSURING NUTRITIONAL SECURITY**

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**Abstract**

Jambolan fruit exhibits a high concentration of bioactive phenolic compounds, which have the potential to exert beneficial effects on human health. The jambolan plant is known to possess many phenolic compounds, including phenolic acids, flavonoids (primarily anthocyanins, flavonols, flavanols, and flavanonols), and tannins, which are present in its diverse anatomical components. This resource is mostly employed for the cultivation of timber and the establishment of fruit orchards. The fruit has been attributed with a range of properties including anti-diabetic, anti-hyperlipidemic, anti-oxidant, anti-ulcer, hepatoprotective, anti-allergic, anti-arthritic, anti-microbial, anti-inflammatory, anti-fertility, anti-pyretic, anti-plaque, radioprotective, neuropsychopharmacological, nephroprotective, and anti-diarrheal effects. The jambolan fruit skin contains a high concentration of anthocyanins, specifically delphinidin, petunidin, and malvidin in glycosylated forms. On the other hand, the majority of the fruit pulp is composed of phenolic acids, including gallic acid and ellagic acid, as well as tannins. Moreover, it has been asserted that the jambolan fruit contains a plethora of other chemicals. Flavonoids such as quercetin, myricetin, and flavonol glycosides have been identified in the leaves of the jambolan tree, as well as in the skin and pulp of its fruit. Jambolan possesses phenolic compounds that have been associated with a wide range of health advantages, including inflammation, allergies, blood sugar regulation, cancer prevention, cardiovascular well-being, radiation treatment support, bacterial infections, chemotherapy efficacy, and more benefits. This chapter provides a comprehensive analysis of the pharmacological, nutritional, and physiological advantages associated with jamun, along with an examination of the diverse bioactive components present in this fruit. Jamun seeds contain both the alkaloid jambosine and the glycoside jambolin, which is also referred to as antimellin.

The fruit commonly known as jamun (Syzygium cumini) has garnered attention in recent years due to its high content of antioxidants and potential contributions to nutritional security. Jamun is rich in bioactive chemicals that have been associated with various health benefits.

In this paper, we will discuss the topic of climate change and its impact on global ecosystems

Phytochemicals are a class of food additives that have demonstrated the capacity to confer health advantages, such as a less susceptibility to chronic ailments, but lacking inherent nutritional value. Phenolic compounds, a chemical family found in plants, have garnered the attention of researchers due to their possible antioxidant properties (Ignat et al., 2011; Singh et al., 2016). Certain types of these molecules, such as tannins, possess unfavorable characteristics, leading to the initial perception of these chemicals and other secondary metabolites in plants as antinutrients (Treutter, 2010). The prevailing notion has been conclusively debunked by the abundance of epidemiological studies that have established the significance of phenolic chemicals in conferring health advantages to individuals. The recent change in mindset has captured the attention of scientists in the field of food technology and allied disciplines, who are now focused on the characterization and quantification of phenolic chemicals present in various food sources. Jambolan (Syzygium cumini Skeels) is a prominent evergreen tree that is widely distributed in tropical and subtropical regions. It is alternatively referred to as jamun, jambul, black plum, or Indian blackberry. The plant in question belongs to the Myrtaceae family and possesses a significant abundance of phenolic chemicals, as indicated by Tavares et al. (2016). The introduction of this plant to Southern Africa can be attributed to its edible fruits (Baliga et al., 2011; Oliveira et al., 2016). However, it is important to note that the plant's origin lies in India and a significant portion of South-East Asia. In addition to its indigenous distribution in South America and Eastern Africa, jambolan can also be obtained from several countries like Bangladesh, Pakistan, Nepal, Sri Lanka, Indonesia, Malaysia, Burma, and the remaining regions of Indonesia. The references provided by the user include Li et al. (2009) and Ayyanar & Subash-Babu (2012). Florida is among the states in the United States that possesses access to the jambolan fruit. The utilization of this botanical species in traditional Indian medicinal and culinary practices has spanned several centuries (Syama et al., 2017). Its various parts, including fruits, seeds, leaves, and bark, have been recognized as edible. A diverse range of plants yield these botanical components, each of which harbors phytochemicals that may exhibit bioactive properties (Ayyanar & Subash-Babu, 2012).

Throughout decades, this substance has been employed in many alternative medicinal practices for its stomachic, diuretic, anti-diabetic, and diarrheic properties. Although there is a general agreement on the possible medicinal benefits of this herb, there is a notable absence of robust scientific data to support these claims. However, it has been asserted by Singh et al. (2015) and Tavares et al. (2016) that jambolan has been utilized in various processed food products such as wine, juice, frozen yogurt, and muffins, intended for human consumption. Jambolan fruit is known to possess many phenolic components, including phenolic acids, flavonoids, and tannins. These chemicals are widely recognized for their capacity to counteract detrimental free radicals. According to a study conducted by Lestario et al. (2017), the jambolan fruit contains anthocyanins that have significant antioxidant capabilities. Anthocyanins, because to their water solubility, possess the ability to be employed as colorants in both food and nonfood substances that include substantial amounts of liquid (Veigas et al., 2007). Jambolan fruit contains a diverse range of secondary chemicals, including anthocyanins such as cyanidin, petunidin, malvidin, and their respective glucosides. The compounds encompassed in this group consist of ellagic acid, gallic acid, quercetin, myricetin, kaempferol, condensed tannins, and hydrolysable tannins. The pharmacological significance of the plant arises from the existence of bioactive chemicals that possess a diverse range of health-promoting properties (Afify et al., 2011). According to Afify et al. (2011), jambolan possesses several pharmacological properties, including antioxidant, antibacterial, chemopreventive, anti-inflammatory, anti-allergic, anti-hyperglycemic, anti-cancer, cardioprotective, radioprotective, and radioprotective activities.

Jambolan contains phenolic chemicals. Phenolic compounds, which are bioactive secondary phytochemicals, are predominantly synthesized in higher plants by either the shikimic acid or phenylpropanoid pathways. Phytochemicals are predominantly found in the external layers of plant tissues and in seeds, where they exhibit defensive properties. Singh et al. (2016) have classified these substances as phenolic acids, flavonoids, and tannins, based on the quantity of phenolic hydroxyl groups and the structural components connecting benzene rings. Phenolic acids encompass a group of chemical compounds, including caffeic acid and coumaric acid generated from hydroxycinnamic acid, as well as gallic acid and ellagic acid obtained from hydroxybenzoic acid. Flavonoids are a class of phenolic compounds characterized by a structural arrangement of C6-C3-C6, wherein two aromatic rings are interconnected by a heterocyclic ring composed of three carbon atoms. Several examples of these substances are flavonols, flavanols, flavones, flavanones, isoflavones, and anthocyanins. Tannins possess a taste characterized by bitterness and astringency, and have molecular weights typically ranging from 500 to 3000, rendering them phenolic compounds that are soluble in water. Phenolic compounds find application in the food business for their preservation properties, ability to enhance flavors, and serve as colorants, with a particular emphasis on anthocyanins, which belong to the flavonoid family. Various methods exist for the detection of total phenolic content, with the Folin-Ciocalteu reagent being the most used. This method entails the reduction of phosphomolybdic or phosphotungstic acid in an alkaline solution, resulting in the formation of a complex that exhibits a distinct blue coloration. Furthermore, the utilization of mass spectrometry enables the confirmation of the existence of phenolic chemicals. In the context of high-performance liquid chromatography (HPLC) analysis, it is common practice to only utilize reversed phase C18 columns. Binary solvent systems commonly employ polar solvents in the majority of instances. It is necessary to obtain fresh samples in order to extract phenolic compounds from fruits such as jambolan. Nevertheless, due to the inherent perishability of these fruits, freeze drying or other preservation processes are commonly necessary. The quantity of phenolic chemicals present in an extract may exhibit significant variability, contingent upon the specific methodology employed during its preparation. Numerous techniques outlined in the existing body of research are characterized by a significant investment of time and complexity in terms of reproducibility (Aqil et al., 2014). Several extremely efficient procedures have been documented in the literature for the preparation of jambolan extract from fruits and seeds, resulting in a substantial production of phenolic chemicals (Veigas et al., 2007; Aqil et al., 2012). The concentration of Jambolan pulp and seed extracts was achieved through the utilization of column chromatography, employing Amberlite XAD-761 and Diaion HP-20 resin. The application of hydrolysis using 2N HCl was employed to enhance the quality of the extracts obtained by the utilization of acidified 75% ethanol, XAD-761, and HP-20 resins. This process facilitated the conversion of ellagitannins into ellagic acid and anthocyanins into anthocyanins. The methodology yielded an extract with a comparatively elevated level of anthocyanin content, measuring at 0.54%. The study conducted by Veigas et al. (2007) investigated the extraction of anthocyanins from jambolan pulp with an alternative resin, Amberlite XAD-7. In a manner akin to pomegranate juice, jambolan juice exhibits a considerable presence of phenolic compounds, albeit with less knowledge regarding their specific characteristics and properties. In a study conducted by Tavares et al. (2017), it was shown that the degradation of anthocyanins in jambolan juice is more pronounced compared to flavonols. This characteristic facilitates the extraction of hydrolysable tannins. Furthermore, it was observed that the anthocyanin concentration in the juice decreased as the dehydration temperature increased throughout the foam mat drying process. On the other hand, hydrolyzable tannins and flavonols were shown to be more susceptible to oxidation and longer heating durations. The researchers discovered that the advantageous constituents, such as anthocyanins, present in jambolan juice had a notable degradation when subjected to processing temperatures exceeding 70 °C.

Flavonoids are a class of natural compounds that are widely distributed in the plant kingdom

Faria et al. (2011) discovered that jambolan fruit extracts, including both the pulp and peel, exhibited a diverse range of flavonols and flavanonols. The compounds identified in the study encompassed myricetin, myricetin pentoside, myricetin rhamnoside, myricetin glucoside, and myricetin acetylrhamnoside. Tavares et al. (2016) identified and quantified various flavanols in jambolan fruit pulp. These flavanols include myricetin 3-O-glucoside, syringetin 3-O-galactoside, myricetin 3-O-pentose, myricetin 3-O-rhamnose, syringetin 3-O-glucoside, myricetin 3-O-glucuronide, laricitrin 3-O-glucoside, laricitrin 3-O-galactoside, and myricetin 3-O-galactoside. The respective quantities of these flavanols were determined to be 30.31, 17.74, 11.55, 10.64, 8.92, 7.53, 5.82, 5.00, and 2.50 mg kg^-1 fresh weight (FW). In contrast, Tavares et al. (2016) identified several flavanols in the peel of jambolan fruit, including myricetin 3-O-glucoside, myricetin 3-O-rhamnose, myricetin 3-O-glucuronide, laricitrin 3-O-glucoside, myricetin 3-O-pentose, syringetin 3-O-glucoside, syringetin 3-O-galactoside, myricetin 3-O-galactoside, and laricitrin 3-O-galactoside. The respective concentrations of these flavanols were reported as 64.4, 11.92, 8.0, 5.04, 3.21, 2.13, 1.91, 1.76, and 1.62 mg kg-1 FW.

According to Tavares et al. (2016), the fresh weight (FW) of jambolan fruit pulp was found to contain 64.54 mg kg-1 of flavanonol dihexosides, specifically dihydromyricetin, methyldihydromyricetin, methyl-dihydroquercetin, and dihydroquercetin. According to Tavares et al. (2016), the fruit peel exhibited concentrations of flavanonol dihexosides at levels of 53.56 mg kg 1 FW for dihydromyricetin, 20.58 mg kg 1 FW for dimethyl-dihydromyricetin, 11.66 mg kg 1 FW for dihydroquercetin, and 6.67 mg kg 1 FW for dimethyl-dihydromyricetin. The study conducted by Lestario et al. (2017) identified three compounds in freeze-dried jambolan fruit extract, namely myricetin 3-O-pentoside, myricetin 3-O-hexoside, and myricetin 3-O-rhamnoside.

The analysis of freeze-dried jambol revealed the presence of five distinct anthocyanins. Among these, four were identified as 3,5-O-diglucosides, specifically petunidin 3,5-O-diglucoside, cyaniding 3,5-O-diglucoside, delphinidin 3,5-O-diglucoside, and peonidin-3,5-O-diglucoside. Additionally, one anthocyanin was identified as a 3-O-gluco Delphinidin. The concentrations of these anthocyanins in freeze-dried jambolan fruit extract were determined to be 256, 245, 166, 75, and 29 mg/100 g DW, respectively, according to a study conducted by Brito et al. in 2007. Singh et al. (2016) reported the presence of delphinidin (20.2 mg mL 1) in freeze-dried jambolan fruit pulp extract. Jambolan pulp has been shown to contain trace quantities of delphinidin, petunidin, and malvidin (3,5-O-diglucosides) with concentrations of 40.39, 30.29, and 23.93 mg kg 1 FW, respectively (Tavares et al., 2016). In a study conducted by Tavares et al., it was observed that the 3,5-O-diglucosides of delphinidin, petunidin, and malvidin were the predominant anthocyanins found in jambolan peel, with concentrations of 37.61, 33.27, and 23.31 mg kg 1 FW, respectively. On the other hand, the 3-O-glucosides of delphinidin, cyanidin, and malvidin were present in much smaller quantities, with concentrations of 1.59, 0.37, and 0.17 mg kg 1 FW, respectively. It was also noted that the anthocyanin concentration in young jambolan fruit is generally low, but increases as the fruit ripens and reaches maturity.

Tannins are a class of polyphenolic compounds commonly found in various plant species.

Accurate determination of the structure of condensed tannins, which are formed through the condensation of flavans, as well as hydrolyzed tannins that release gallic or ellagic acids upon hydrolysis, necessitates the utilization of intricate and advanced methodologies. The astringency of jambolan fruit is attributed to the presence of hydrolyzable tannins. Hydrolyzable tannins, specifically ellagitannins and gallotannins, as well as condensed tannins in the form of proanthocyanidins, have been identified in both the peel and pulp of jambolan fruit (Gordon et al., 2011; Tavares et al., 2016). Zhang and Lin (2009) made the discovery of ellagitannins, which are hydrolyzable tannins, in jambolan fruit. The tannins under consideration possess a central glucose core that is enveloped by units of gallic acid and ellagic acid. In their study, Gordon et al. (2011) conducted the isolation and characterization of twelve gallotannins, one hexahydroxydiphenoyl (HHDP)-gallotannin, and one trisgalloyldiglucose from the extract of jambolan fruit, namely from its peel and pulp. These compounds were identified as hydrolysable tannins. The compounds known as gallic acid, nonahydroxytriphenolyl (NHTP), hydroxyhexyldiphenol (HHDP), trisgalloyl, and valoneic acids have been identified as the fundamental constituents of hydrolysable tannins (Gordon et al., 2011; Tavares et al., 2016). The Jambolan fruit is known to possess a diverse range of hydrolyzable tannins, with gallotannins being the most abundant (Tavares et al., 2016). Furthermore, it was observed that the hydrolysable tannin concentration in the peel of jambolan fruit was greater in gallotannin compared to the pulp. The predominant gallotannin isomers found in the pulp and peel of fruits were monogalloylglucose and tetragalloylglucose, respectively. Besides monogalloyl to trigalloylglucose, the gallotannins found in fruit pulp encompassed a range of isomers, including trigalloylglucose, pentagalloylglucose, and hexagalloylglucose. Additionally, other isomers identified in these gallotannins spanned from digalloyl to hexagalloylglucose. In a study conducted by Lestario et al. (2017), it was demonstrated that gallotannins extracted from jambolan fruit consist of galloyl, trigalloyl to hexagalloyl glucose, and gallic acid. According to Tavares et al. (2016), the skin of the jambolan fruit contains ellagitannins with galloyl or trisgalloyl-HHDP substituents. On the other hand, the pulp of the fruit contains ellagitannins with HHDP and NHTP substituents, including castalagin, vescalagin, trisgalloyl-HHDP-glucose, and diHHDP-glucose isomers.

The peel and pulp of jambolan fruit were discovered to have prodelphinidins with a high degree of galloylation. These prodelphinidins are mostly made of oligomeric and polymeric flavan-3-ols, which consist of subunits such as gallocatechin and epigallocatechin (Tavares et al., 2016). The research findings indicate that the Jambolan fruit extract exhibits a total proanthocyanidin content of 453 g cyanidin chloride equivalent per gram of fresh weight (FW). The study conducted by Luximon-Ramma and colleagues in 2003. According to the study conducted by Tavares et al. (2016), the peel and pulp of the jambolan fruit were discovered to contain condensed tannins, with a condensed tannin content (CTC) of 11.92 and 9.03 mg catechin equivalents [CE]/kg fresh weight, respectively. According to the findings of Brandao et al. (2011) and Lestario et al. (2017), it has been observed that the tannin content of jambolan fruit decreases as it through the process of ripening and maturation.

The extent or level of phenolic compounds

Table 1 presents the determined total phenolic content (TPC) for different components of the jambolan plant. According to Ali et al. (2015), the peel of the jambolan fruit exhibited a considerably higher total phenolic content (TPC) compared to the combined TPC of the pulp and seed. According to Bajpai et al. (2005), the jambolan seed crude extract contains ellagic acid (38 µg/g), gallic acid (646 µg/g), quercetin (98 µg/g), and kaempferol (59 µg/g). According to Aqil et al. (2012), the amounts of total phenolic compounds (TPC) in jambolan pulp and seed powder are 1.15 percent and 2.69 percent, respectively. In their study, Arun et al. (2011) documented the total phenolic compound (TPC) concentrations in various solvents. The TPC concentrations were found to be 16,833 mg GAE/100 g in water, 47,167 mg GAE/100 g in ethanol, 23,000 mg GAE/100 g in acetone, and 37,500 mg GAE/100 g in ethyl acetate. The study conducted by Mohamed et al. (2013) found that the methanolic and methylene chloride extracts of Jambolan leaf contained 1403 and 655 mg GAE/100 g DW of total phenolic compounds (TPC), respectively. According to Brandrao et al. (2011), the phenolic components in jambolan fruit were shown to be more abundant at the unripe stage, but their concentration dropped as the fruit underwent ripening.

The total quantity of flavonoids

Table 1 presents the data on the total flavonoid content (TFC) of several parts of the jambolan plant. The study conducted by Ali et al. (2015) revealed that the highest levels of TFC were found in the skin of the fruit, followed by the pulp and seed. According to Arun et al. (2011), the quantities of TFC in the water, ethanol, acetone, and ethyl acetate extracts were measured to be 6531, 11,488, 10,386, and 13,826 quercetin equivalents [QE] mg/100 g, respectively. The extraction of flavonoids has been proposed to be conducted using methanol as an alternative to methylene chloride. In a study conducted by Mohamed et al. in 2013, it was found that the total flavonoid content (TFC) in methanolic and methylene chloride extracts of jambolan leaf were measured to be 622 and 204 mg QE g 1 DW, respectively. The freeze-dried extract of jambolan fruit pulp was found to contain a total phenolic compound (TFC) content of 573 mg QE/100 g. According to a study conducted in 2016 by Singh et al., the flavanonol content was measured to be 1676.8 mg/100 g FW, while the naringin content was found to be 63.7 mg/100 g FW. Similarly, the jambolan peel and pulp were seen to have 701.9 and 43.1 mg myricetin 3-O-glucoside equivalents/100 g FW, respectively. Another study conducted in 2016 by Tavares et al. also examined this topic.

The concentration of anthocyanins in its whole.

The present study provides data on the total anthocyanin content (TAC) of several portions of the jambolan plant. The anthocyanin concentration of jambolan fruit undergoes changes during the maturation process. The fresh jambolan fruit contained a concentration of 79 milligrams of TAC per 100 grams. In 2007, a team of researchers led by Brito conducted a study. According to the findings of Reynertson et al. (2008), freeze-dried jambolan fruit extract was found to possess a total antioxidant capacity (TAC) similar to 663 mg of cyanidin 3-O-glucoside (C3G) per 100 g. In a study conducted by Tavares et al. (2016), it was found that the collective total antioxidant capacity (TAC) of fruit extract, encompassing both peel and pulp, was measured to be 31.55 mg/100 g FW. This measurement was expressed in terms of malvidin 3,5-O-diglucoside equivalents. The total acidity content (TAC) in immature jambolan fruits is quite low, but exhibits a significant increase as the fruits through the ripening process. The total antioxidant capacity (TAC) in unripe jambolan fruits is significantly low; however, it undergoes a substantial increase when the fruit reaches its ripening stage. According to Lestario et al. (2017), the total phenolic content (TAC) in various stages of jambolan fruit, including green-yellow, green-pink, pink, red, light purple, dark purple, and completely mature black, was determined to be 28.5 mg/100 g dry weight (DW).

Numerous fruits possess anthocyanins and flavonoids, which exhibit heightened antioxidant properties in comparison to conventional phenols. Furthermore, aside from their role in the prevention of free radical production, these compounds also have the ability to hinder the scavenging or deactivation of free radicals (Singh et al., 2016; 2017). The antioxidant effects of Jambolan are derived from its abundant concentration of phenolic components. The antioxidant activity exhibited by the peel of fruits surpasses that of the pulp and seed due to the larger concentration of bioactive constituents present in the peel. According to Ali et al. (2015), the antioxidant properties of jambolan fruit peel, pulp, and seed were determined to be 90.6%, 82.5%, and 85.2% correspondingly, in terms of their ability to scavenge free radicals. According to Lestario et al. (2017), the jambolan fruit is recognized for its significant concentration of anthocyanins, which contribute to its abundant antioxidants and natural colorants.

The jambolan fruit extract exhibited a Trolox equivalent antioxidant capacity (TEAC) of 970 lmol TE/g at pH 7.0, and an oxygen radical absorbance capacity (ORAC) of 1640 lmol TE/100 g at pH 7.4. According to the findings of a study conducted by Faria et al. in 2011, it was shown that the antioxidant capacity of hemiacetals and/or chalcones, which are the colorless variants of anthocyanins that can be obtained in phosphate buffer at pH levels of 7.0 or 7.4, surpasses that of the flavylium cation. According to Aqil et al. (2012), the jambolan pulp exhibited ORAC values of 144.5 mM TE/100 g, but the jambolan seed hydrolysates demonstrated values of 337.9 mM TE/100 g. According to Afify et al. (2011), the compound known as kaempferol's methyl ether demonstrates efficacy as a scavenger of free radicals. According to the findings of Aqil et al. (2012), the ability to scavenge radicals was attributed partially to the existence of cis-diols in ellagic acid/ellagitannins, catechol (orthodihydroxyl), and pyrogallol (vicinal trihydroxyl) groups within pigments generated from cyanidin and delphinidin.

According to Mohamed et al. (2013), the FRAP value of jambolan leaf extracts in methanol was determined to be 1314 mg ascorbic acid equivalents (AAE) per 100 g dry weight (DW), while in methylene chloride, the value was found to be 122 mg AAE per 100 g DW. The observed antioxidant activity of jambolan leaves can be partially ascribed to the significant amounts of total phenolic content (TPC) and total flavonoid content (TFC) discovered in polar extracts, specifically methanolic extracts. The ethanol extract of jambolan fruit possesses tannins that have a notable capacity to reduce the levels of free radicals. According to Ramirez and Roa (2003), the administration of jambolan chemicals possessing antioxidant capabilities at a dosage of 20 g/kg body weight has shown efficacy in the prevention of gastrointestinal ulcers in rats. Various extracts from numerous medicinal plants have demonstrated scavenging properties. However, the extract derived from jambolan bark has shown exceptional efficacy in decreasing peroxidation, as observed in a study conducted by Sultana et al. in 2007. The study conducted by Veigas et al. (2007) revealed that the extract derived from the peel of the jambolan fruit exhibited a significant level of free radical-scavenging activity, with a DPPH scavenging activity of 78.2%. Notably, this high antioxidant activity was observed even at a remarkably low concentration of 2.5 parts per million (ppm). These findings imply that the jambolan fruit peel extract has promise as a potential natural source of antioxidant chemicals.

The jambolan fruit and seed have been found to contain phenolic acids, which have demonstrated several beneficial properties such as antioxidant, anti-diabetic, anti-cancer, anti-inflammatory, antibacterial, anti-allergic, and free radical scavenging activities (Aqil et al., 2016; Singh et al., 2016; Ghosh et al., 2017; Seraglio et al., 2018). According to Ayyanar and Subash-Babu (2012), the utilization of jambolan fruits and seeds in traditional medicine encompassed the treatment of several ailments such as diarrhoea, colds, coughs, fevers, skin conditions, and gastrointestinal disorders. Several investigations have indicated that the utilization of jambolan fruit extracts may potentially mitigate the likelihood of cancer development (Li et al., 2009) as well as diabetes (Grover et al., 2000; Ravi et al., 2005; Sharma et al., 2006; Helmst€adter, 2008). According to Aqil et al. (2012), the development of human lung cancer A549 cells was inhibited by hydrochloric acid-hydrolyzed extracts derived from jambolan pulp and seed. The extractability of Jambolan pulp powder was found to be 30%, which decreased to 4% following enrichment. In contrast, the enriched seed powder exhibited a lower extractability of 3%. Furthermore, the consumption of jambolan fruit has been observed to possess a calming impact on the gastrointestinal tract. The research conducted by Brito et al. (2007) examined the anti-allergic properties of jambolan leaf extract. Their findings revealed that the extract exhibited preventive effects on oedema development, histamine and serotonin production, mast cell degranulation, and eosinophil accumulation in mice. The flavonoid glycosides found in jambolan leaf extract have been associated with anti-inflammatory and anti-oedematogenic activities due to their ability to inhibit enzymes involved in cell activation and the production of inflammatory mediators. Protection against radiation-induced DNA damage can be achieved through the utilization of bioactive chemicals included in jambolan (Jagetia et al., 2008). Superoxides are effectively neutralized by these compounds, which subsequently safeguard cellular membranes against potential harm. The study conducted by Jagetia et al. (2005) demonstrated the radioprotective benefits of an extract derived from jambolan seeds. The extract was synthesized using dichloromethane and methanol. The experiment involved exposing mice to different doses of c-radiation.

Mice that received a prior administration of jambolan seed extract at a dosage of 80 mg per kg of body weight exhibited a significant level of protection against the adverse effects of illness and mortality induced by exposure to c-radiation. The radioprotective action of jambolan seed extract can be attributed to the presence of bioactive compounds like as flavonoids and ellagic acid, which exhibit free radical scavenging properties. According to a study conducted by Jagetia et al. (2008), the application of Jambolan leaf extract demonstrated a protective effect against DNA damage generated by gamma radiation in human peripheral cells cultivated in vitro and exposed to a dose of 3 Gy.

In summary, and considering future prospects

The phenolic components and antioxidant properties of jambolan provide it a valuable component in the formulation of nutritious and functional food products. Nonetheless, a comprehensive examination of the physiological advantages associated with these chemicals necessitates a comprehensive understanding of their bioavailability. There remain a multitude of unresolved inquiries, and the majority of the existing knowledge regarding the safety of these pharmaceuticals is derived from in vitro and animal model experiments. There are a multitude of opportunities available for further study in this particular discipline. The phenolic chemicals present in jambolan exhibit potential activities that need further exploration through rigorous clinical trials and comprehensive epidemiological investigations. Further investigation is warranted to explore the methodologies employed in the processing of jambolan fruits with the objective of mitigating the degradation of their advantageous constituents. Jambolan and its derivatives have not gained significant traction in impoverished nations, lacking a firmly established market. Furthermore, developed countries have not fully capitalized on the potential of this chemical. The utilization of clinical investigations and phytochemical analysis can enhance the medical and pharmaceutical recognition of this plant.

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**Declaration of Conflict of Interest**

The authors declare that they have no conflict of interest.

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