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Syzygium jambos (L.) Alston (Rose Apple): A Review of its Phytochemistry and Pharmacology

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GRAPHICAL ABSTRACT

PHARMACOLOGY OF SYZYGIUM JAMBOS (L.) ALSTON



***Syzygium jambos* (L.) Alston**

MAIN METABOLITES

Flavonoids
Tannins
Triterpenoids
Organic Acids
Phenolic Acids



PHARMACOLOGICAL AND BIOLOGICAL PROPERTIES

Antioxidant
Antibacterial
Neurological
Hepatoprotective
Pancreatoprotective
Immunomodulatory
Anti-inflammatory
Antidiabetic
Cardiovascular

ABSTRACT: *Syzygium jambos* L. Alston (Myrtaceae), commonly known as “pomarrosa”, “jambolero”, “rose apple”, “yambo”, among others, is a wild species found in Asia and America. It grows on the western slopes of northern Peru in rocky or stony and moderately sub-xerophytic environments at altitudes ranging from 1,500 to 2,200 meters above sea level. The objective of this review is to compile scientific information on *S. jambos*, focusing on its phytochemistry as a potential source of novel bioactive compounds and its therapeutic applications. The literature search was conducted using electronic databases such as Scopus, ScienceDirect, PubMed Central, and the Google Scholar search engine. A total of 33 documents in English and Spanish were selected. A bibliographic review of *S. jambos* reveals that this plant species is rarely utilized in traditional medicine. However, further research is required to explore its phytochemistry as a potential source

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of novel bioactive compounds, as well as its pharmacological properties, contemporary applications, and toxicological profile with scientific validation. The collected data indicate its efficacy in various *in vitro* and *in vivo* pharmacological activities, including antimicrobial, antiviral, anti-inflammatory, antimutagenic, antinociceptive, antipyretic, antispasmodic, antithrombotic, apoptotic, cardiovascular, chemomodulatory, antitumor, hepatoprotective, hypoglycemic, hypolipidemic, and memory-enhancing effects. Despite the diversity of pharmacological activities of *S. jambos*, further studies on clinical assays and the development of formulations must be carried out. Hence, *S. jambos* has emerged as a valuable source in traditional medicine and provides a significant foundation in pharmaceutical biology for the development and formulation of new drugs and future clinical applications.

1. INTRODUCTION

Syzygium jambos (L.) Alston, also referred to as *Jambosa jambos*(L.) Mill sp., *Eugenia jambos*, *Myrtus jambos*(L.) Kunth, *Plinia jambos*(L.), *Myrtus jambos*(L.) Kunth, *Eugenia malaccensis*Lour., *Eugenia monantha*Merr., and *Eugenia malaccensis*Blanco, belongs to the Myrtaceae family and is mainly known as “pomarroza”, “jambolero”, “rose apple”, “yambo”, “jambo”, among others (Growables, 2021). It is a tall tree, reaching approximately 20 meters in height, with a highly branched structure. The species produces large flowers with numerous stamens measuring 3 to 4 cm in length, exhibiting a white coloration. The fruits are bright red, pear-shaped, sweet, and edible, emitting a fragrance reminiscent of rose petals. This species is native to Southeast Asia and is also found in America, adapted to different biomes. In Peru, for example, *S. jambos* is found thriving on the western slopes of the northern region in rocky or stony environments with semi-xerophytic characteristics, at altitudes ranging from 1,500 to 2,200 meters above sea level (López-Vergara and Ortega, 2022). In turn, this species is found in Brazil in the Atlantic Forest, between sea level and 1,000 meters above. Although native to tropical Asia, *S. jambos* is also cultivated in tropical America for its ornamental value, attributed to its striking red and fuchsia flowers, dense foliage that provides ample shade, and palatable fruit. It is also commonly found in Central America, including Costa Rica, El Salvador, and Belize, as well as in Venezuela and Ecuador (Filian Murrieta and Velásquez, 2017).

The species exhibits rapid growth and can attain heights of 12 to 18 meters, developing a pyramidal crown. Its leaves are evergreen, opposite, and have short petioles, with an elliptic-lanceolate to oblanceolate shape and a glossy, dark green adaxial surface. Initially, the flowers display a deep red

hue, transitioning to pinkish tones over time. These flowers are highly abundant and nearly scentless, emerging from the upper trunk and the most mature branches. The fruit is oval-shaped, measuring between 5 and 10 cm in length and 2.5 to 7.5 cm in width. It possesses thin, waxy, pink-colored skin. The edible pulp is white, slightly crisp, spongy, and highly succulent, characterized by a mild and slightly sweet flavor. The fruit typically contains a single oval seed; however, in some cases, it may contain up to two nearly round or hemispherical seeds, measuring approximately 2 cm in diameter. The seeds exhibit a brown exterior and a green, fleshy interior (Mayhuasque Hernández, 2015).

According to León Lincango (2015), this fruit originates from the species known as “Jambeiro,” belonging to the genus *Syzygium*, within the Myrtaceae family, which includes fruit-bearing plants such as cherries, eucalyptus, and guavas. Among the most well-known species within this genus are the red jambo (*Syzygium malaccense*), which is sweet with a slightly acidic taste; the white jambo (*Syzygium*), characterized by its mild flavor; and the rose jambo (*Syzygium jambolana*), which produces pink-colored fruits (León Lincango, 2015).

Ávila-Peña et al. (2007) state that the levels of phenolic compounds in medicinal plants can be influenced by environmental factors such as soil composition, precipitation, temperature, and humidity (Ávila-Peña et al., 2007). The tannin content in the plant may vary throughout its growth in response to changing environmental conditions. Studies have investigated the environmental influence on secondary metabolites and the chemical variability in certain species of the Myrtaceae family (Borges et al., 2013).

In species of *S. jambos*, research has also been conducted on chemical variability and environmental factors that may affect essential oil composition (Rezende et al., 2013). Environmental parameters such as soil composition, rainfall, temperature, and humidity are known to influence the concentration of phenolic compounds in medicinal plants. According to Rezende et al. (2015), variations in these factors markedly affect the synthesis of phenolic metabolites in the leaves of *Syzygium jambos*. Their study identified that the main determinants of phenolic content in this species include foliar nutrients (Fe, Mo, P, Ca, K, Na, and Co), soil elements (Mn, S, K, Na, and Al), and climatic conditions, particularly temperature and precipitation.

2. METHODOLOGY

The systematic compilation of scientific information was conducted using the databases Science Direct, PubMed Central®, Scielo, Scopus, Alicia, and the Google Scholar

search engine. The search employed combinations of the following keywords: (*Syzygium jambos*) AND (Antioxidant OR Endogenous Antioxidants OR Antioxidant Activity OR Antioxidant Effects) AND (Immunomodulations OR Immunomodulatory Therapies), (*Syzygium jambos*) AND “pharmacological effect”, and (*Syzygium jambos*) AND (ethnomedicine OR phytochemistry OR “pharmacological effect”). This exploration led to the identification of 110 documents, from which 38 articles were selected (34 original research papers, 2 systematic reviews, and 2 theses), covering the period from 1983 to 2025, in English and Spanish.

3. LITERATURE REVIEW

3.1. Botanic Taxonomy

Category	Name
Kingdom	Plantae
Division	Tracheophyta
Subdivision	Spermatophyta
Infradivision	Angiospermae
Class	Magnoliopsida
Superorder	Rosanae
Order	Myrtales
Family	Myrtaceae
Genus	<i>Syzygium</i>
Species	<i>Syzygium jambos</i>

3.2. Phytochemical Composition

3.2.1. Leaves

Chemical characterization of *Syzygium jambos* leaf extracts revealed the presence of numerous secondary metabolites, including flavones, flavonol glycosides, flavonol diglycosides, phenolic acids, and ellagitannins, as determined by HPLC-PDA-MS/MS analysis. The isolation and structural elucidation of individual compounds were carried out using spectroscopic methods, particularly one-dimensional NMR techniques (¹H-NMR and ¹³C-NMR) (Slowing et al., 1994; Sobeh et al., 2018; Wong et al., 2024; Bonfanti-Azzolin et al., 2019) (Table 1).

3.2.2. Bark

The study by Mahmoud et al. (2021) revealed the following secondary metabolites: HHDP-hexoside, bis-HHDP-hexoside, phyllanthuslin g, castalagin, vescalagin, ellagic acid pentoside, methyl ellagic sulfate, and ellagic acid (Mahmoud et al., 2021) (Table 1).

Table 1. Phytochemical compounds from *Syzygium jambos* leaves.

Metabolites	Extraction Method	Reference		
Flavonoids				
Hexahydroxydiphenoyl-hexoside	LC-MS/MS	(Sobeh et al., 2018)		
Galloyl-HHDP-DHHDP-hexoside				
Bis-HHDP-hexoside				
Galloyl-bis-HHDP-hexoside				
Ellagic acid pentoside				
Ellagic acid rhamnoside				
Myricetin rhamnoside				
Myricetin 3-O-xylosyl-rhamnoside				
Rosmarinic acid rhamnoside				
Quercetin 3-O-xylosyl-hamnoside				
Catechin	HPLC	(Bonfanti-Azzolin et al. 2019)		
Rutin				
Epicatechin				
Isoquercitrin				
Quercitrin				
Kaempferol	NMR	(Wong et al., 2024)		
Myricetin derivative				
Kaempferol derivative				
Myrigalone G				
Quercetin glucuronide				
Myricetin glucoside	UPLC-MS/MS	(Wong et al., 2024)		
Quercetin xyloside				
Quercetin galloylglucoside				
Myricetin robinoside				
Myricetin xylosyl-rhamnoside				
Jaceidin rhamnoside				
Quercetin arabinoside				
Quercetin rhamnoside				
Quercetin xylosyl-rhamnoside				
Kaempferol rhamnoside-xyloside				
Tannins				
Castalagin	NMR	(Wong et al., 2024)		
Casuarinin				
Vescalagin				
Vescalin				
di-Hexahydroxydiphenoyl (HHDP) glucose				
Galloyl castalagin				
Trigalloyl glucose				
Tellimagrandin II				
Coriariin A				
Coriariin B				
Praecoxin A	UPLC-MS/MS	(Wong et al., 2024)		
Praecoxin B				
Strictinin				
Pterocarinin A				
Tellimagrandin I				
(-)-Epigallocatechin	NMR	(Wong et al., 2024)		
Triterpenoids				
Stigmasterol			NMR	(Wong et al., 2024)
Lupeol				
β-amyrin				
Pomolic acid				
Friedelin				

(Continued)

Table 1: (Continued)

Metabolites	Extraction Method	Reference
Madecassic acid	UPLC-MS/MS	(Wong et al., 2024)
Asiatic acid		
Maslinic acid		
Oleanolic acid		
Organic Acids		
Malic acid	LC-MS/MS	(Sobeh et al., 2018)
Citric acid		
Ellagic acid		
Ellagic acid hexoside		
Phenolic Acids		
Caffeic acid	HPLC	(Bonfanti Azzolin et al., 2019)
Gallic acid		
Chlorogenic acid		
Syringic acid		
Gallic acid coumaroyl hexose		
Sugars		
α-glucose	NMR	(Wong et al., 2024)
β-glucose		
Fructose		
Raffinose	UPLC-MS/MS	(Wong et al., 2024)
Fatty acids		
Trihydroxy octadecadienoic acid	UPLC-MS/MS	(Wong et al., 2024)
Trihydroxy octadecenoic acid		
Hydroxy-docosanoic acid		
Other metabolites		
Valine	NMR	(Wong et al., 2024)
Alanine		
Choline		
Formic acid		
Stigmasterol glucoside	UPLC-MS/MS	(Wong et al., 2024)
Pheophorbide A		
Methyl hydroxydocosanoate		

LC-MS/MS: Liquid Chromatography–Mass Spectrometry
HPLC: High-Performance Liquid Chromatography
MS: Mass Spectrometry

3.2.3. Fruit

The total phenolic content in *S. jambos* fruit was 127.61 mg GAE/100 g, while the seed contained 217.34 mg GAE/100 g. Additionally, the flavonoid content in the fruit was measured at 8.64 mg QE/100 g (Dutta et al., 2023). Moreover, the rose apple fruit is rich in carbohydrates, calcium, phosphorus, vitamin C, β-carotene, and iron (León Lincango, 2015) (Table 1).

3.3. Pharmacological and Biological Properties

3.3.1. Antimicrobial activity

Leaves

Rajkumari et al. (2018a) reported that ethanolic leaf extracts of *Syzygium jambos* were fractionated and analyzed through activity-guided HPLC profiling. Two major bioactive

compounds, 5-hydroxymethyl-2-furfural and betulin, were identified as key contributors to the plant’s anti-quorum sensing (anti-QS) properties. This activity interfered with quorum sensing (QS)-regulated virulence mechanisms in *Pseudomonas aeruginosa*. At concentrations below the minimum inhibitory level (sub-MIC), the extract notably disrupted QS signaling, resulting in decreased production of virulence factors and inhibition of biofilm development. Molecular docking studies further demonstrated that these phytochemicals displayed high binding affinities toward the QS transcriptional regulators LasR and RhlR, surpassing those of the native signaling molecules 3-oxo-C12-HSL and C4-HSL. These findings underscore the potential of *S. jambos* and its bioactive compounds as quorum sensing antagonists, offering a promising therapeutic approach for treating chronic infections caused by *P. aeruginosa* (Rajkumari et al., 2018a) (Table 2).

Bark

The *in vitro* antibacterial activity of acetone and aqueous extracts of *S. jambos* bark was analyzed using the agar dilution method in Petri plates. These extracts demonstrated notable efficacy against *Yersinia enterocolitica*, *Staphylococcus aureus*, and several coagulase-negative *Staphylococcus* strains, including *Staphylococcus hominis*, *Staphylococcus cohnii*, and *Staphylococcus warneri*. Furthermore, the research conducted by Djadjo Djipa et al. (2002) suggests that the high tannin concentration in *S. jambos* bark extracts, as measured by the European Pharmacopoeia method (77% in aqueous extracts and 83% in acetone extracts), is directly associated with antimicrobial properties. Comparatively, extracts from *Hamamelis virginiana*, *Alchemilla vulgaris*, *Krameria triandra*, and *Rubus fruticosus* exhibited lower tannin levels, at 48%, 46%, 44%, and 28%, respectively. Notably, complete tannin removal resulted in a total loss of antimicrobial activity, confirming their essential role in the bioactivity of *S. jambos* (Djadjo Djipa et al., 2000) (Table 2).

3.3.2. Antioxidant activity

Seeds

Phenolic compounds, such as flavonoids, are natural pigments widely found in nature. They possess a chemical structure that enables them to function as antioxidants by scavenging free radicals and neutralizing reactive oxygen species (ROS) and metal ions. Due to their reactivity, they are often combined with organic acids, sugars, or polymerized with each other (Cartaya et al., 2001). Furthermore, phenolic compounds play a fundamental role in plant development and, in their interaction with humans, protect the body from oxidative damage. Additionally, they are used in the treatment of cardiovascular disorders and in the prevention of certain types of cancer (Škerget et al., 2005).



Table 2.Pharmacological and biological properties of *S. jambos*.

Pharmacological Properties	Sample	Experimental Assay	Bioactive Compounds	Authors
Antioxidant	50% ethanolic seed extract	<i>In vitro</i> models: ABTS and DPPH	Phenols, proanthocyanidins, flavones and flavonols	(Škerget et al., 2005)
	Aqueous pulp extract	<i>In vivo</i> : diabetic rats	NI	(Pandita et al., 2022)
	Leaf extract	<i>In vivo</i> : <i>Caenorhabditis elegans</i>	Polyphenols	(Sobeh et al., 2018)
Antibacterial	Ethanol leaf extract	<i>Pseudomonas aeruginosa</i>	5-hydroxymethyl-2-furfural and betulin	(Dutta et al., 2023)
Neurological	Ethyl acetate and hexane fractions	Strongest anti-AChE potential	Anacardic acid derivatives 4 and 5	(Amir Rawa et al., 2022)
	Methanolic leaf extract	<i>In vivo</i> : CCl ₄ -intoxicated rats; <i>In vitro</i> : human liver cells	Phenolic compounds	(Sobeh et al., 2018)
Hepatoprotective and pancreatoprotective		<i>In vivo</i> : paracetamol intoxicated Wistar albino rats	NI	(Selvam et al., 2013)
	Aqueous bark extract	<i>In vivo</i> : streptozotocin-induced diabetes in rats	HHDP-hexoside, bis-HHDP-hexoside, phyllanthuslin g, castalagin, vescalagin, ellagic acid pentoside, methyl ellagic sulfate and ellagic acid	(Mahmoud et al., 2021)
Immunomodulatory	Hydroethanolic leaf extract	<i>In vitro</i> : rat spleen lymphocytes	Gallic, chlorogenic, and ellagic acids, catechin, epicatechin, rutin, quercetin, isoquercitrin, quercetin, and kaempferol	(Bonfanti Azzolin et al., 2019)
Anti-inflammatory	Methanolic and ethyl acetate leaf extract	<i>In vivo</i> : rats in acute and chronic inflammation model (carrageenan)	NI	(Slowing et al., 1994)
Antidiabetic	Hydroalcoholic seed extract	<i>In vivo</i> : hyperglycemic rats fed high-caloric diets	Vitamin C, Glutathione	(González Blas, 2022)
Cardiovascular	Ethyl acetate fraction from aqueous naïve leaf extract (boiled)	<i>In vitro</i> : isolated hind limb from dog	NI	(Romero, 1995)
	Lyophilized leaf extract	<i>In vivo</i> : human polymorphonuclear and mononuclear cells	Gallic acid, Rutin	(Inostroza-Nieves et al., 2022)

NI = Not Informed

Various laboratory studies have shown the antioxidant effects of alcoholic extracts from seeds. These extracts exert their effects through different mechanisms, such as chelation of transition metal catalysts like ferric ions and scavenging of free radicals, including 2,2-diphenyl-1-picrylhydrazyl (DPPH), hydroxyl, superoxide, nitric oxide, and lipid peroxide. The antioxidant capacity of the seed extract has been observed to vary with concentration, exhibiting a potency six times higher than that of Trolox against the superoxide radical (Vasi and Austin, 2009). Animal studies on skin cancer formation indicated that oral administration of the seed extract could significantly increase levels of both non-enzymatic antioxidants (such as glutathione and vitamin C) and antioxidant enzymes (such as catalase and superoxide dismutase), while simultaneously reducing lipid peroxidation (Parmar et al., 2011). Several researchers have investigated the antioxidant potential of the pulp through *in vitro* assays, including

hydroxyl radical scavenging, lipid peroxidation, superoxide radical scavenging, and DPPH assays (Khan et al., 2015). Another study reported that *S. jambos* seeds contain flavonoids with potent antioxidant and free radical scavenging activity, as demonstrated in DPPH assays, which could contribute, at least in part, to their traditionally recognized therapeutic benefits (Zheng et al., 2011). Additional research has confirmed the presence of alkaloids, flavonoids, glycosides, phytosterols, saponins, triterpenoids, and tannins in the alcoholic extract of the seed (Khan et al., 2015).

In a recent study, Liu et al. (2022) identified a key factor for assessing how different variables influence the extraction of triterpenoids from *S. jambos* seeds, using yield as the primary reference measure. Additionally, the antioxidant activity of triterpenoids from the seeds was evaluated by determining their free radical scavenging capacity through DPPH and ABTS assays. The results indicated that the most efficient

extraction conditions included a methanol concentration of 44.30%, a solid-to-liquid ratio of 1:47.18 g/mL, and an extraction time of 101.07 minutes (rounded to 101 minutes). The IC₅₀ values obtained were 24.93 µg/mL for DPPH radical scavenging and 12.16 µg/mL for ABTS radical scavenging. A dose-dependent relationship was observed between antioxidant activity and sample concentration, demonstrating an effective and feasible optimization process. The triterpenoids extracted from *S. jambos* exhibited in vitro antioxidant activity, providing complementary insights into the potential use of seeds in food and medicinal applications (Liu et al., 2022). In another study, Duttas et al. (2023) also reported the high antioxidant capacity of the seed extract, indicating that it can be considered a potential resource for the prevention and treatment of oxidative stress-related diseases, including gout, arthritis, diabetes, cardiovascular diseases, neurodegenerative diseases, cancer, and respiratory tract infections (Duttas et al., 2023) (Table 2).

Leaves

The fruit of *Syzygium jambos* contains numerous phytochemicals with potent antioxidant properties capable of scavenging free radicals. These compounds contribute to both the prevention and mitigation of oxidative stress, a condition arising when the generation of reactive oxygen species (ROS) surpasses the cell's antioxidant defense capacity (Duttas et al., 2023).

In vitro evaluations of total phenolic content (TPC), DPPH radical scavenging, nitric oxide (NO•) scavenging, and inhibition of α-amylase and α-glucosidase activities revealed that the 70% ethanolic leaf extract exhibited the strongest bioactive potential across all assays. Metabolite profiling by ultra-high-performance liquid chromatography–electrospray ionization quadrupole-Orbitrap tandem mass spectrometry (UHPLC/ESI Q-Orbitrap MS/MS) and nuclear magnetic resonance (NMR) spectroscopy led to the tentative identification of 59 and 30 metabolites, respectively. Based on this chemical profile, tannins, flavonoids, and triterpenes were identified as the predominant bioactive classes, supporting the antioxidant and antihyperglycemic activities of the *S. jambos* leaf extract (Wong et al., 2024).

The pathogenesis of chronic diseases such as atherosclerosis, cancer, arthritis, and neurodegenerative disorders is closely associated with the excessive production and insufficient clearance of reactive oxygen species, including superoxide anion (O₂^{•−}), hydroxyl radical (•OH), and hydrogen peroxide (H₂O₂).

Plants possess a natural ability to produce a diverse range of enzymatic and non-enzymatic antioxidants, which can mitigate oxidative damage caused by reactive oxygen species

(ROS). The ethanolic leaf extracts from *Syzygium jambos* and *Terminalia citrina* Roxb. demonstrated significant in vitro antioxidant activity compared to the natural antioxidant ascorbic acid. Rajkumari et al. (2018b) reported that, during their study, these extracts exhibited a strong protective effect against oxidative stress-induced damage in hydrogen peroxide (H₂O₂)-treated *Saccharomyces cerevisiae* mutant strains (tsa1Δ and sod1Δ). Identification of the leaf extracts by gas chromatography-mass spectrometry (GC-MS) revealed the presence of plant-derived compounds, predominantly terpenes, fatty acids, and vitamins, which contribute to their antioxidant properties. These plant extracts could serve as a valuable source of exogenous antioxidants to counteract the detrimental effects of oxidative stress (Rajkumari et al., 2018b) (Table 2).

Fruit

The antioxidant potential of *Syzygium jambos* pulp was further validated using carotene bleaching, ferric reducing antioxidant power (FRAP), and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assays (Rufino et al., 2010). Additionally, the in vivo antioxidant activity of the aqueous pulp extract was assessed in streptozotocin-induced diabetic rats. The treatment significantly enhanced hepatic antioxidant enzyme levels, including catalase, glutathione peroxidase, glutathione-S-transferase, reduced glutathione (GSH), and superoxide dismutase (SOD), indicating a protective effect against oxidative stress and highlighting the pulp as a promising source of antioxidants in the body (Pandita et al., 2022) (Table 2).

3.3.3. Neurological activity

Leaves

Macaranga tanarius (MT) and *Syzygium jambos* (SJ) have been recognized for their antioxidant, anti-inflammatory, and antidiabetic activities, with growing evidence supporting their potential neuroprotective roles. In the study conducted by Amir Rawa et al. (2022), leaf extracts of both species demonstrated substantial inhibition of acetylcholinesterase (AChE) activity—76.32% for MT and 93.81% for SJ—at a concentration of 50 µg/mL in their respective ethyl acetate and hexane fractions. The investigation aimed to identify the bioactive constituents responsible for this effect and to elucidate the molecular mechanisms underlying AChE inhibition. Through bioassay-guided fractionation, prenylated flavonoids (1–3) were isolated from MT, while anacardic acid derivatives (4 and 5) were obtained from SJ, as confirmed by NMR and mass spectrometric analyses. Among these compounds, derivative 5 exhibited the strongest AChE inhibitory activity (IC₅₀ = 0.54 µM), followed by compounds 1, 4, 3, and 2 (IC₅₀ = 1.0, 2.4, 6.8, and 33 µM, respectively). Molecular

docking simulations indicated that compound 5 established stronger binding interactions, including three hydrogen bonds, than compound 4—an effect attributed to its saturated alkyl chains. Additionally, the presence of a five-carbon prenyl moiety in compound 1 enhanced its interaction with the enzyme's active site, explaining its superior inhibitory potency compared to derivatives 2 and 3. This study constitutes the first identification of AChE inhibitors from these two plant species, emphasizing their potential as novel neuroprotective candidates (Amir Rawa et al., 2022) (Table 2).

3.3.4. Hepatoprotective and pancreatoprotective activities

Leaves

Sobeh et al. (2018) demonstrated that treatment with *Syzygium jambos* leaf extract in rats subjected to acute CCl₄-induced hepatotoxicity led to a marked decrease in hepatic injury biomarkers, including ALT, AST, total bilirubin (TB), total cholesterol (TC), triglycerides (TG), and malondialdehyde (MDA), while simultaneously elevating glutathione (GSH) and superoxide dismutase (SOD) levels. These hepatoprotective effects were comparable to those produced by silymarin. In cultured hepatocytes, pretreatment with *S. jambos* extract significantly attenuated the generation of reactive oxygen species (ROS) triggered by sodium arsenite exposure and increased GSH content, without altering the phosphorylation of p38 MAPK or its downstream target MAPKAPK-2. These results suggest that *S. jambos* exerts its hepatoprotective action primarily through free radical scavenging and inhibition of ROS formation (Sobeh et al., 2018).

Similarly, Selvam et al. (2013) found that pre-administration of methanolic extracts from *S. jambos* leaves (100 and 200 mg/kg) mitigated paracetamol-induced hepatic injury in rats, resulting in reduced serum levels of bilirubin, SGOT, SGPT, and ALP, thereby improving overall liver function markers. Histopathological examination confirmed that the higher dose preserved hepatic cytoarchitecture and reduced cellular degeneration. These findings reinforce the hepatoprotective potential of *S. jambos* leaf extracts and their ability to restore hepatic integrity following toxic insult (Selvam et al., 2013) (Table 2).

Bark

Mahmoud et al. (2021) evaluated the antidiabetic and pancreatic protective effects of *Syzygium jambos* bark extract in a streptozotocin (STZ)-induced diabetic rat model. The animals received daily oral doses of 100 or 200 mg/kg of the extract, while a control group was administered glibenclamide (0.5 mg/kg). STZ was injected two days before the start of treatment, which continued for 14 consecutive days. In diabetic rats, the induction of diabetes led to marked

hyperglycemia, elevated fructosamine levels, positive glucosuria, and increased pancreatic concentrations of tumor necrosis factor- α (TNF- α), malondialdehyde (MDA), and caspase-3. Concurrently, reductions were observed in serum insulin, pancreatic interleukin-10 (IL-10), B-cell lymphoma 2 (BCL-2), reduced glutathione (GSH), as well as phosphorylated hepatic protein kinase B (p-AKT), glucose transporter 4 (GLUT4), and insulin receptor substrate 2 (IRS2) in hepatic tissue. On the other hand, all these values were mitigated in the treated groups, such that the higher dose displayed an effect comparable to the glibenclamide treatment. These findings demonstrate the significant oxidative and inflammatory disturbances associated with STZ-induced diabetes and suggest that *S. jambos* bark extract may offer protective and regulatory effects on glucose metabolism and pancreatic function (Mahmoud et al., 2021) (Table 2).

3.3.5. Immunomodulatory activity

Leaves

Bonfanti-Azzolin et al. (2019) argue that *S. jambos* appears to exhibit immunomodulatory effects by enhancing mitochondrial activity in lymphocytes and inhibiting AChE activity. Some findings suggest potential adverse effects of these plant-derived products, which could be valuable for therapeutic decision-making and future toxicological research on these extracts when used as herbal medicines (Bonfanti-Azzolin et al., 2019). On the other hand, part of the immunomodulatory effect can be explained by the high myricetin content in *S. jambos* leaves. Myricitrin, a glycosylated flavonol, is a chemical marker for the *Syzygium* genus (Tian et al., 2011), being found in the myricetin-3-O-rhamnoside form in the ethanol extract from *S. jambos* (Sharma et al., 2013) and in the ethanol extract from *S. aqueum* leaves (Manaharan et al., 2012). This flavonol has antioxidant, anti-inflammatory, antinociceptive, and antigenotoxic actions (Xu et al., 2020). Myricetin can decrease the generation of nitric oxide, myeloperoxidase, and malondialdehyde and increase the activity of superoxide dismutase and glutathioneperoxidase, which could be linked to its antioxidant properties (Park et al., 2016). These findings indicate that the high contents of compounds with strong antioxidant capacity in *Syzygium* species can enable them to prevent the proliferation of cancer cells and mitigate the adverse effects induced by chemotherapy (Singh et al., 2018) (Table 2).

3.3.6. Anti-inflammatory activity

Leaves

S. jambos is traditionally used to alleviate toothaches, oral ailments, cough, wound healing, and infectious diseases. Its anti-inflammatory activity has been reported for the leaf

extract, attributed to its isolated flavonoid glycosides, which are closely related to analgesic activity (Rezende et al., 2015). On the other hand, the fruit is rich in carbohydrates, vitamin C, beta-carotenes, calcium, phosphorus, and iron and exhibits antidiabetic, antiepileptic, and antiseptic properties (Bartra Vasquez, 2019).

Extracts from various *Syzygium* species contain a diverse range of phytochemicals with the potential to modulate different inflammatory processes (Cock and Cheesman, 2009). For instance, phytosterols, which are abundant in the *Syzygium* genus, influence prostacyclin (PGI₂) release by smooth muscle cells and prostaglandin E₂ (PGE₂) release by macrophages, which may play a role in vasodilatory effects associated with inflammation. It was reported that two glycosylated flavonoids were identified in the CH₂Cl₂/MeOH fraction of *S. jambos*: quercetin-3-O-β-d-xylopyranosyl-(1→2)-α-l-rhamnopyranoside and myricetin-3-O-β-d-xylopyranosyl-(1→2)-α-l-rhamnopyranoside. Apaza Ticona et al. (2021) also examined the cytotoxic and anti-inflammatory activities of the isolated compounds. Toxicity was evaluated in RAW 264.7 macrophage cells using the lactate dehydrogenase (LDH) assay, revealing that all compounds displayed markedly lower cytotoxicity than the reference compound, actinomycin D (CC₅₀ = 0.008 μM). The anti-inflammatory and anti-arthritic effects were further assessed through the modulation of inflammatory markers in murine models. Notably, the two glycosylated flavonoids suppressed tumor necrosis factor-alpha (TNF-α) production in RAW 264.7 cells, exhibiting IC₅₀ values of 1.68 and 1.11 μM, respectively. Moreover, when administered at 5 mg/kg, all flavonoids significantly decreased TNF-α, C-reactive protein (CRP), and fibrinogen levels in mice, supporting their potential as anti-inflammatory agents (Apaza Ticona et al., 2021).

In a complementary study, Slowing et al. (1994) assessed the anti-inflammatory activity of four organic extracts obtained from *Syzygium jambos* leaves—hexane, dichloromethane, ethyl acetate, and methanol—in both acute and chronic inflammation models in rats. The extracts were orally administered at doses equivalent to 12.5 g/kg of dried plant material. All extracts demonstrated significant inhibition of both inflammatory phases, with ethyl acetate and methanol extracts exhibiting the strongest effects, comparable to or surpassing those of phenylbutazone (80 mg/kg). The methanolic extract, in particular, showed the greatest efficacy during the chronic inflammatory phase. Additionally, a 10% aqueous infusion tested under the same conditions proved to be more effective than the organic extracts, highlighting the potential therapeutic value of water-based preparations of *S. jambos* (Slowing et al., 1994). In addition, the leaf extract of *Syzygium jambos* was demonstrated to reduce the levels

of the pro-inflammatory cytokines interleukin-8 (IL-8) and tumor necrosis factor-alpha (TNF-α). This finding is consistent with previous studies on *S. samarangense* leaf extracts, which exhibit strong anti-inflammatory capacity, as evidenced by a paw edema test in mice. The anti-inflammatory effect is likely attributed to aurenfiacine chalcone from *S. samarangense*, which induces downregulation of nitric oxide synthase (NOS) levels and cytokine mRNA expression (Sobeh et al., 2018) (Table 2).

3.3.7. Antidiabetic activity

Seeds

A recent study conducted by González-Blas et al. (2022) found that *S. jambos* seed extract exhibits hypoglycemic properties in rats. Additionally, the study identified the presence of triterpenes, steroids, phenols, flavonoids, lactones, alkaloids, tannins, leucoanthocyanidins, reducing sugars, and amino acids in the extract (González-Blas et al., 2022). This fruit-bearing plant has been traditionally used as a dietary supplement, particularly for the treatment of diabetes and other diseases. A separate study investigated the correlation between *S. jambos* leaf metabolites and bioactivities using a metabolomics approach based on proton nuclear magnetic resonance (¹H-NMR). This metabolomics approach provides reliable insights into the potential antioxidant and antihyperglycemic compounds present in *S. jambos* (Wong et al., 2024) (Table 2).

3.3.8. Cardiovascular activity

Leaves

Romero (1995) reported that the aqueous extract of *Syzygium jambos* leaves exerts hypotensive and bradycardic effects comparable to those produced by veratridine and capsaicin. More recently, Inostroza-Nieves et al. (2022) demonstrated that the same extract inhibits secreted protein disulfide isomerase (PDI) activity and downregulates interleukin-6 (IL-6) expression, contributing to its antioxidant and anti-inflammatory effects in activated human endothelial and immune cells. Their findings indicated that *S. jambos* polyphenols modulate endothelin-1 (ET-1)-mediated pathways in a dose-dependent manner, thereby preventing ET-1-induced migration of human polymorphonuclear and mononuclear cells and the subsequent increase in reactive oxygen species (ROS) production. Collectively, these results reinforce the pharmacological potential of *S. jambos* phytochemicals in managing endothelial dysfunction and inflammatory disorders. This study highlights the extract's capacity to regulate endothelial activation, cytokine signaling, and immune responses, positioning it as a promising therapeutic candidate for cardiovascular protection (Inostroza-Nieves et al., 2022) (Table 2).

3.4. Toxicity

The toxicity of leaf extract of *S. jambos* was evaluated through *Artemia salina* assays and cytotoxicity evaluations in rat spleen lymphocytes. Several methods were employed, including methyl tetrazolium (MTT) assay, neutral red uptake (NRU) assay, trypan blue exclusion test, and lactate dehydrogenase (LDH) leakage assays. Additionally, the in vitro effect of the extract on acetylcholinesterase (AChE) activity was assessed. According to Bonfanti-Azzolin et al. (2019), the LC50 derived from the *Artemia salina* bioassay was 362.70 ppm, which suggested a low potential for toxic effects of the extract, and it also appears to present immunomodulatory effects by enhancing lymphocyte mitochondrial activity and decreasing AChE activity (Bonfanti-Azzolin et al., 2019).

CONCLUSION

Syzygium jambos is a potential source of bioactive compounds, including flavonoids such as catechin, rutin, epicatechin, isoquercitrin, quercitrin, kaempferol, and quercetin, as well as acids such as malic, citric, ellagic, chlorogenic, caffeic, and gallic acids, among others. Moreover, quercetin is highlighted as the most abundant compound. The aerial parts of *S. jambos* exhibit pharmacological properties with therapeutic applications, including antioxidant, antibacterial, neurological, hepatoprotective, immunomodulatory, anti-inflammatory, antidiabetic, and hypotensive activities.

AUTHOR CONTRIBUTIONS

All authors have read and agreed to the published version of the manuscript.

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COMPETING INTERESTS

The authors declare no conflicts of interest.

AUTHORSHIP CONTRIBUTION STATEMENT

CESC was responsible for idealization, conceptualization, supervision and wrote the article. ADGS reviewed the pharmacological aspects and approved the article. MVGS reviewed the chemical aspects. KACG, NNCG and MLSC selected the article. GDGG structured the article. RDDGA wrote and made the overall revision.

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REFERENCES

- Amir Rawa, M.S., Nurul Azman, N.A., Mohamad, S., Nogawa, T., & Wahab, H.A. (2022). In vitro and in silico anti-acetylcholinesterase activity from *Macaranga tanarius* and *Syzygium jambos*. *Molecules*, 27, 2648. <https://doi.org/10.3390/molecules27092648>
- Apaza Ticona, L., Souto Pérez, B., Martín Alejano, V., & Slowing, K. (2021). Anti-inflammatory and anti-arthritis activities of glycosylated flavonoids from *Syzygium jambos* in edematogenic agent-induced paw edema in mice. *Revista Brasileira de Farmacognosia*, 31, 429–441. <https://doi.org/10.1007/s43450-021-00167-0>
- Ávila-Peña, D., Peña, N., Quintero, L., & Suárez-Roca, H. (2007). Antinociceptive activity of *Syzygium jambos* leaves extract in rats. *Journal of Ethnopharmacology*, 112, 380–385. <https://doi.org/10.1016/j.jep.2007.03.027>
- Bartra Vasquez, G.L. (2019). Aprovechamiento del contenido nutricional de la fruta de pomarrosa (*Syzygium jambos* (L.) Alston) con pulpa de Camu (*Myrciaria dubia* H.B.K. Mc Vaugh) como fuente de vitamina C, en la elaboración de mermeladas- Pucallpa. *Bachelor's Thesis*, Universidad Nacional de Ucayali, Peru.
- Bonfanti-Azzolin, G., Leal Zambra, A., Morgan da Silva, B., Santos De Bona, K., Eliete Rodrigues Bitencourt, P., Cargnelutti, L., Maleski Borges, R., De Freitas, M.L., Brandão, R., Woutheres Bortolotto, J., Augusti Boligon, A., Pigatto, A.S., Moretto, M.B., & de Lima Gonçalves, T. (2019). Toxicity assessment of *Syzygium jambos* and *Solanum guaraniticum* hydroethanolic leaf extracts thru *Artemia salina* lethality and spleen lymphocyte cytotoxicity tests. *International Journal of Innovation Education and Research*, 7, 133–143. <https://doi.org/10.31686/ijer.vol7.iss10.1758>

- Borges, L.L., Alves, S.F., Sampaio, B.L., Conceição, E.C., Bara, M.T.F., & Paula, J.R. (2013). Environmental factors affecting the concentration of phenolic compounds in *Myrcia tomentosa* leaves. *Revista Brasileira de Farmacognosia*, 23, 230–238. <https://doi.org/10.1590/S0102-695X2013005000019>
- Cartaya, O. (2001). Reseña bibliográfica flavonoides: características químicas y aplicaciones. *Cultivos Tropicales*, 22, 5–14.
- Cock, I.E., & Cheesman, M. (2009). The potential of plants of the genus *Syzygium* (Myrtaceae) for the prevention and treatment of arthritic and autoimmune diseases. In *Bioactive food as dietary interventions for arthritis and related inflammatory diseases* (pp. 401–424). Elsevier, Amsterdam, Netherlands. <https://doi.org/10.1016/B978-0-12-813820-5.00023-4>
- Djipa, C.D., Delmée, M., & Quetin-Leclercq, J. (2000). Antimicrobial activity of bark extracts of *Syzygium jambos* (L.) Alston (Myrtaceae). *Journal of Ethnopharmacology*, 71, 307–313. <https://doi.org/10.4000/books.irdeditions.7350>
- Dutta, S., Halder, S., & Khaled, K.L. (2023). Phytochemical investigation and in vitro antioxidant activity of *Syzygium jambos* fruit and its seed. *Asian Journal of Pharmaceutical and Clinical Research*, 16, 35–40. <https://doi.org/10.22159/ajpcr.2023.v16i2.46496>
- Filiani Murrieta, A., & Velásquez, J. (2017). Desarrollo de una composta a base de pomarrosa (*Syzygium malaccense* L.), fortificada con harina de amaranto (*Amaranthus caudatus* L.). *Bachelor's Thesis*, Universidad Católica de Santiago de Guayaquil, Ecuador.
- González-Blas, M.V., García-Armas, J.M., & Herrera-Gutiérrez, L.A. (2022). Flavonoides y fenoles totales con actividad hipoglucemiante en semillas de *Syzygium jambos*. *Revista Salud Amazónica y Bienestar*, 1, e272–e272.
- Growables. (2021). Rose apple - *Syzygium jambos*. <https://www.growables.org/information/TropicalFruit/RoseApple.htm> (accessed May 5, 2025).
- Inostroza-Nieves, Y., Valentin-Berrios, S., Vega, C., Prado, G.N., Luciano-Montalvo, C., Romero, J.R., & Rivera, A. (2022). Inhibitory effects of *Syzygium jambos* extract on biomarkers of endothelial cell activation. *BMC Complementary Medicine and Therapies*, 22, 101. <https://doi.org/10.1186/s12906-022-03572-7>
- Khan, M.K., Anjum, F.M., Arshad, M.U., & Hassan, S. (2015). *Eugenia jambos*. *RPMP*, 45, 1–33.
- León Lincango, J. (2015). Estudio investigativo de la pomarrosa y su aplicación en la gastronomía. *Bachelor's Thesis*, Universidad Tecnológica Equinoccial, Ecuador.
- Liu, J., Chen, X., Zeng, H., Wang, S., & Xiang, L. (2022). Optimization of the extraction process of triterpenoids from the seeds of *Syzygium jambos* L. Alston by response surface methodology and its antioxidant activity. *Science and Technology of Food Industry*, 43, 192–199. <https://doi.org/10.13386/j.issn1002-0306.2022020016>
- López-Vergara, I., & Ortega, C. (2022). Evaluación de la actividad antioxidante de la pomarrosa (*Syzygium malaccense*) en condiciones de congelación a 0°C, -10°C y -20°C. *Bachelor's Thesis*, Universidad De Guayaquil, Ecuador.
- Mahmoud, M.F., Abdelaal, S., Mohammed, H.O., El-Shazly, A.M., Daoud, R., El Raey, M.A., & Sobeh, M. (2021). *Syzygium jambos* extract mitigates pancreatic oxidative stress, inflammation and apoptosis and modulates hepatic IRS-2/AKT/GLUT4 signaling pathway in streptozotocin-induced diabetic rats. *Biomedicine and Pharmacotherapy*, 142, 112085. <https://doi.org/10.1016/j.biopha.2021.112085>
- Manaharan, T., Appleton, D., Cheng, H., & Palanisamy, U. (2012). Flavonoids isolated from *Syzygium aqueum* leaf extract as potential antihyperglycaemic agents. *Food Chemistry*, 132, 1802–1807. <https://doi.org/10.1016/j.foodchem.2011.11.147>
- Mayhuasque Hernández, C. (2015). Mermelada de *Syzygium malaccense* pomarrosa, enriquecida con camu *Myrciaria dubia* H.B.K. Mc Vaugh. Bachelor's Thesis, Universidad Nacional De Ucayali, Peru.
- Pandita, D., Pandita, A., & Bhanu, C. (2022). *Antidiabetic plants for drug discovery* (Vol. 1). Apple Academic Press, Palm Bay, United States. <https://doi.org/10.1201/9781003282938>
- Park, K., Chong, Y., & Kim, M. (2016). Myricetin: Biological activity related to human health. *Applied Biological Chemistry*, 59, 259–269. <https://doi.org/10.1007/s13765-016-0150-2>
- Parnar, J., Sharma, P., Verma, P., & Goyal, P.K. (2011). Modulation of DMBA-induced biochemical and histopathological changes by *Syzygiumcumini* seed extract during skin carcinogenesis. *International Journal of Current Biomedical and Pharmaceutical Research*, 1, 24–30.
- Rajkumari, J., Borkotoky, S., Murali, A., & Busi, S. (2018a). Antiquorum sensing activity of *Syzygium jambos* (L.) Alston against *Pseudomonas aeruginosa* PAO1 and identification of its bioactive components. *South African Journal of Botany*, 118, 151–157. <https://doi.org/10.1016/j.sajb.2018.07.004>
- Rajkumari, J., Dyavaiah, M., Sudharshan, S.J., & Busi, S. (2018b). Evaluation of in vivo antioxidant potential of *Syzygium jambos* (L.) Alston and *Terminalia citrina* Roxb. towards oxidative stress response in *Saccharomyces cerevisiae*. *Journal of Food Science and Technology*, 55, 4432–4439. <https://doi.org/10.1007/s13197-018-3355-z>
- Rezende, W.P., Borges, L.L., Alves, N.M., Ferri, P.H., & Paula, J.R. (2013). Chemical variability in the essential oils from leaves of *Syzygium jambos*. *Revista Brasileira de Farmacognosia*, 23, 433–440. <https://doi.org/10.1590/S0102-695X2013005000035>
- Rezende, W.P., Borges, L.L., Santos, D.L., Alves, N.M., & Paula, J.R. (2015). Effect of environmental factors on phenolic compounds in leaves of *Syzygium jambos* (L.) Alston (Myrtaceae). *Modern Chemistry and Applications*, 3, 1000157.
- Romero, J. (1995). Acción cardiovascular de extractos acuosos de hojas de *Syzygium jambos* (L.) Alston. *Revista Costarricense Ciencias Médicas*, 16, 17–25.
- Rufino, M. do S. M., Alves, R. E., de Brito, E. S., Pérez-Jiménez, J., Saura-Calixto, F., & Mancini-Filho, J. (2010). Bioactive compounds and antioxidant capacities of 18 non-traditional tropical fruits from Brazil. *Food Chemistry*, 121, 996–1002. <https://doi.org/10.1016/j.foodchem.2010.01.037>
- Selvam, N., Venkatakrishnan, V., Dhamodharan, R., Murugesan, S., & Kumar, S. (2013). Hepatoprotective activity of methanolic extract of *Syzygium jambos* (Linn.) leaf against paracetamol intoxicated Wistar albino rats. *Ayu*, 34, 305.
- Sharma, R., Kishore, N., Hussein, A., & Lall, N. (2013). Antibacterial and anti-inflammatory effects of *Syzygium jambos* L. (Alston) and isolated compounds on acne vulgaris. *BMC Complementary and Alternative Medicine*, 13, 29.
- Singh, K., Bhoori, M., Kasu, Y., Bhat, G., & Marar, T. (2018). Antioxidants as precision weapons in the war against cancer

- chemotherapy-induced toxicity by exploiting the arsenal of obscurity. *Saudi Pharmaceutical Journal*, 26, 177–190. <https://doi.org/10.1016/j.jsps.2017.12.013>
- Škerget, M., Kotnik, P., Hadolin, M., Hraš, A.R., Simonič, M., & Knez, Ž. (2005). Phenols, proanthocyanidins, flavones and flavonols in some plant materials and their antioxidant activities. *Food Chemistry*, 89, 191–198. <https://doi.org/10.1016/j.foodchem.2004.02.025>
- Slowing, K., Carretero, E., & Villar, A. (1994). Anti-inflammatory activity of leaf extracts of *Eugenia jambos* in rats. *Journal of Ethnopharmacology*, 43, 9–11. [https://doi.org/10.1016/0378-8741\(94\)90110-4](https://doi.org/10.1016/0378-8741(94)90110-4)
- Sobeh, M., Esmat, A., Petruk, G., Abdelfattah, M., Dmirieh, M., Monti, D.M., Abdel-Naim, A., & Wink, M. (2018). Phenolic compounds from *Syzygium jambos* (Myrtaceae) exhibit distinct antioxidant and hepatoprotective activities in vivo. *Journal of Functional Foods*, 41, 223–231. <https://doi.org/10.1016/j.jff.2017.12.055>
- Tian, L., Xu, M., Wang, D., Zhu, H., Yang, C., & Zhang, Y. (2011). Phenolic constituents from the leaves of *Syzygium forrestii* Merr. and Perry. *Biochemical Systematics and Ecology*, 39, 156–158. <https://doi.org/10.1016/j.bse.2011.01.014>
- Vasi, S., & Austin, A. (2009). Antioxidant potential of *Eugenia jambolana* Lam. seeds. *Journal of Biological Sciences*, 9, 894–898. <https://doi.org/10.3923/jbs.2009.894.898>
- Wong, P.L., Ramli, N.S., Tan, C.P., Azlan, A., & Abas, F. (2024). NMR-based metabolomics and UHPLC-ESI-MS/MS profiling of *Syzygium jambos* in relation to their antioxidant and anti-hyperglycemic activities. *Arabian Journal of Chemistry*, 17, 105546. <https://doi.org/10.1016/j.arabjc.2023.105546>
- Xu, Z., He, W., Liu, C., & Kong, J. (2020). Enzymatic synthesis of myricetin 3-O-galactoside through a whole-cell biocatalyst. *Chinese Herbal Medicines*, 12, 384–389.
- Zheng, N., Wang, Z., Chen, F., & Lin, J. (2011). Evaluation of the antioxidant activity of total flavonoid extract from *Syzygium jambos* seeds and optimization by response surface methodology. *African Journal of Pharmacy and Pharmacology*, 5, 2411–2419.