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Syzygium cumini (L.) SKEELS: A POTENTIAL SOURCE OF NUTRACEUTICALS

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ABSTRACT

Syzygium cumini (L.) Skeels, commonly known as Jamun, is a widely distributed forest tree in India and other tropical and sub tropical regions of the world. The tree has a great economic importance since most of the parts like the bark, leaves, seed and fruits are used as an alternative medicine to treat various diseases. It is used in well known traditional medicines to control the blood sugar level in the patients suffering from diabetes. The tree is rich in phytochemicals like glycoside jambolin, anthocyanins, tannins, terpenoids, gallic acid and various minerals. These wide ranges of health promoting compounds make them a suitable candidate to be used as a nutraceutical. The fruits are purplish black in colour when ripe and have high anthocyanin content. It is a seasonal fruit and is consumed fresh for its nutrient value. Fruits are also processed to make jam, jellies, squash, vinegar and ice cream for its beautiful and attractive purple colour. There are many commercial herbal brands in India and other Asian countries which manufacture these products and are very popular among the consumers. Even though there has been a number of successful research on the medicinal properties of S. cumini extracts in animal models and in vitro animal cell lines there are no reports on clinical trial experiments to study the in vivo effect of the phytochemicals on human beings. We suggest that there is a need to do further research and study the suitability of this tree extracts as a nutraceutical.

KEYWORDS: *Anthocyanins, Jamun, Nutraceutical, Phytochemicals, Processed food, Syzygium cumini.*

INTRODUCTION

There has been an increasing demand for health promoting food products by the consumers all over the world. This has led to the new hybrid term between nutrients and pharmaceuticals, 'nutraceuticals' coined by Dr. Stephen L. DeFelice, in the year 1989[1]. Nutraceuticals are diet supplements that deliver a concentrated form of a bioactive component from a food and used with the purpose of enhancing health in dosages that sometimes exceeds that of the normal foods [2]. Nutraceutical foods are not subject to the same testing and regulations as any of the new pharmaceutical drugs since its components are already used by humans. The nutraceuticals can either be taken as dietary supplements or as functional foods. The dietary supplements can be in the form of liquid concentrates or capsules whereas functional foods are enriched foods which are very close to the original natural food.

In the traditional medicine systems consumption of plant derived food has always been shown to have health benefits which is mainly associated with the phytochemical constituents such as polyphenols present in some plants. Among the phytochemicals the naturally occurring plant pigments that provide many bright and attractive colours have gained much interest among the researchers due to the attractive appearance they give to the food. There are four main types of pigments present in the plants: chlorophyll, carotenoids, betalains and flavonoids. Excluding chlorophyll which is green, the other three pigments provide a range of colours to the plant. Carotenoids are synthesized in the chloroplast and are lipid soluble. They confer red to orange colour to the fruits and flowers. Betalains are water soluble and give yellow to red colouration to fruits and vegetable. They are synthesized and stored in the vacuoles. Flavonoids which include anthocyanins are a diverse group of secondary metabolites and are one of the best characterized natural products in plants. Among the flavonoids, anthocyanin gives some fruits and flowers their pink, red, magenta, purple and dark blue colours. These pigments are synthesized in the cytosol and are localized in the vacuoles of the plant cells [3].

Anthocyanins also have antioxidant ability, potentially serving as an *in vivo* defense against the plant hypersensitive pathogen responses. It also protects the plants from damage caused by UV radiation. A growing number of scientific and epidemiological reports suggest that anthocyanins or the anthocyanin extracts exhibit a wide range of

protective effects with potential benefits for human and animal health[4, 5]. Besides anthocyanins have shown to have antagonistic activity to some bacteria, virus and fungi and thus also protect food from microbial spoilage [6]. Most of the bioactivity and health properties of anthocyanin have been proved experimentally with the help of *in vitro* studies. The health benefits are mainly due to the antioxidant activities towards free radicals and reactive oxygen species. The free radical scavenging activity of anthocyanins which has a protective role on the animal cell death gives an anti aging property to the fruits or vegetables. The reason for an increasing demand of these flavonoids is their role as attractive natural colourants which also adds nutritive value to the food consumed by the consumers and thus acting as a nutraceutical.

Syzygium cumini

Syzygium cumini L., (syn. *Eugenia jambolana, Eugenia cumini* and *Syzygium jambolana*) a polyembryonic species (family Myrtaceae) [7], is a tropical fruit tree of great economic importance (**fig. 1**).

Figure 1. *S. cumini* tree in its natural habitat

Figure 2. Ripe fruits of *S. cumini*

The fruit is commonly known as jamun (Hindi), java plum, black plum, jambul and Indian blackberry. It is a large, evergreen widely distributed forest tree of India, Sri Lanka, Malaysia and Australia which is also cultivated for its edible fruits. The tree was introduced from India and tropical Asia to southern Africa for its edible and attractive fruits. It has been successfully introduced to many tropical countries like West Indies, East and West Africa and some sub tropical regions like Florida, California, Algeria and Israel for its commercial importance.

The flower appears during the month of March to April and the fruit formation takes place about 32 days after flowering during the month of May to July. The ripe fruits (**fig. 2**) are purplish black in colour. The bark contains a good amount of lignin[8]. The various important chemical constituents of *S. cumini* are listed in the **table 1**.

ECONOMIC IMPORTANCE

Almost all parts of the tree are used for various purposes. Ripe fruits are very juicy, almost odorless, with a pleasant, slightly bitter, astringent taste. The fruit pulp is used to make jams, jellies, juice, vinegar and puddings. Fruits are also used to make wine in vast quantities in the Philippines.

An interesting feature of the *S. cumini* wood is that it is very strong and also water as well as termite resistant. The wood is used to install motors in the wells. It is a fast-growing tree, which provides excellent firewood and charcoal. The leaves are used as fodder and as food for tassar silkworms in India. The leaf distillates yield an essential oil which is used as fragrance in soaps and is blended

with other chemicals to make inexpensive perfumes. *S. cumini* flowers are rich in nectar and are useful in the apiculture for their yield of high quality honey.

Table 1. Phytochemicals in *S. cumini*

Sl. No.	Plant part	Phytochemicals
1.	Edible pulp	Vitamin C Vitamin A Riboflavin Nicotinic acid Choline Folic acid Malaic acid Sugar Amino acids Na, K, Ca, P, Fe, Zn, Mn
2.	Seed	Glycoside jamboline
3.	Seed and bark	Gallic acid
4.	Stem and bark	Tannins Resin Phytosterols
5.	Seed and leaves	Essential oils
6.	Flower	Terpenoids

Table 2. Health benefits from various parts of the *S. cumini* plant studied *in vitro*.

Sl. No.	Health benefits	Plant part	References
1.	Diabetes	Leaf Bark Seed Pulp	[32] [33] [34] [35]
2.	Anti allergic	Leaf	[36]
3.	Antioxidant	Leaf Fruit Seed	[13] [17] [37] [15]
4.	Anti Viral	Leaf	[38]
5.	Anti Bacterial	Leaf Seed	[39] [40] [41]
6.	Anti cancer	Fruit	[42] [43] [44]
7.	Anti inflammation	Seed Seed Leaf	[45] [46] [47]
8.	Gastric ulcer	Seed	[48]
9.	Antihyperlipidemic	Fruit	[49]
10.	DNA damage	Leaf	[50]

Table 3. Processed food from the fruit available in the Asian market*:

Sl. No.	Product	Manufacturer	Location
1.	Juice and squash	A.I. International	Mumbai, Maharashtra
		Konkan Bazar	Mumbai, Maharashtra
		Disha Consultancy services	Kolhapur, Maharashtra
		Hahneman Charitable Mission Society	Jaipur, Rajasthan
		Aloecare Arogya Life	Mumbai, Maharashtra
		Kamadhenu Ventures Pvt. Ltd.	Singapore
		Sree Guruji	Indore, M.P
2.	Ice-cream	Natural Ice-creams	Mumbai, Maharashtra
		Fruity freeze	Kolkata, W.B
		Gelato Vinto	New Delhi
		Fresh and Naturelle	Kolkata, W.B
		Shankar	Ahmedabad, Gujarat
3.	Vinegar	Vikash Bharti	Gumla, Jharkhand
		Shanti Kunj Krishi Ghar	Ghaziabad, U.P
		D.R.V. Marketing Pvt. Ltd.	Ghaziabad, U.P
		Sushev agricultural farms	Pilibhit, U.P

*Source: Information freely available online

The seed is used as an alternative natural healing system in the Ayurvedic, Unani and Chinese medicines. Bark of *S. cumini* yields a brown dye due to its high tannin content which is used in tanning leather and preserving fishing nets. The seeds and bark are well known in the Far East for the treatment of dysentery and in control of hyperglycemia and glycosuria in diabetic patients. The astringent bark may be used as a gargle. Fruits are used as a relief for colic, while the wood yields a sulphate pulp that has medicinal uses.

ANTHOCYANINS IN *S. cumini*

S. cumini fruit is a very rich source of anthocyanin [9, 10]. The immature fruits are green in colour and the fruit goes through a number of developmental stages till it gets its purple black colour. Anthocyanin accumulating fruits often display a range of intermediary colours during the fruit development which ranges from green to white to the final colour of the fruit with decreasing chlorophyll levels[11,12]. The accumulation of the pigment finally gives the different shades of pink, red or dark purple colour to the fruits. In case of *S. cumini* the immature fruits which are green in colour first become pale green and transform to a white fruit. This white fruit stage starts accumulating pink colour which turns to a crimson colour and then at final stage the purplish black ripe fruit appears. The anthocyanin present in the fruit also contributes to the numerous health benefits of the fruit and is thus used in the traditional medicines to cure a number of diseases along with the other phytochemicals. The fruit is consumed fresh during the season for its high nutrient value.

There have been many studies to establish the best extraction method for getting the highest amount of nutrients and have been applied to animal cell models. Ruan et. al., 2008, have used different solvents like methanol, water, chloroform, n-hexane and ethyl acetate to determine antioxidant activity of leaf extracts against free radicals like 1,1-diphenyl-2-picrylhydrazy (DPPH) radical[13]. They have also checked the ferric reducing antioxidant power (FRAP). Among these solvents ethyl acetate was found to be the best solvent in terms of antioxidant activity. Another experiment by Kheaw-on et. al, 2009[14] used methanol and acidified methanol to check the total anthocyanin content and antioxidant capacity of the fruit extracts [15]. Acidified methanol was found to be the best solvent in the study.

IDENTIFICATION OF THE ANTHOCYANINS IN THE FRUIT

The type of anthocyanins present can determine many important factors regarding the stability and other properties of the extract. Three types of anthocyanins have been identified in *S. cumini* as glucosides of delphinidin, petunidin and malvidin by HPLC-ESI-MS[16]. The study also used the extracts to check the lipid peroxidation in biological models like rat brain, liver mitochondria, testes and human erythrocytic ghosts. The extract was found to be very active in the animal cell systems. Another HPLC-MS/MS study of *S. cumini* extracts by Brito et.al., 2007 have identified five out of six types of anthocyanins (delphinidin, cyaniding, petunidin, peonidin and malvidin) in their di glucoside forms [17].

Two types of tannins present in the fruits have been identified by NMR, MALDI-TOF MS and HPLC in *S. cumini.* Hydrolysable tannin ellagitannins and condensed tannin epiafzelechins have been identified and the structure has been predicted with the help of NMR[18]. The extracts have been reported to have a good DPPH radical scavenging and FRAP activity which shows that the fruit is a potential source of antioxidants.

USE AS NUTRACEUTICALS

The family Myrtaceae has some of the taxonomically informative molecules like mallic acid, oxalic acid, gallic acid, ellagic acid, betulic acid, tannins, flavonoids and essential oils (**Table 1**). These compounds are present at the different parts of the tree and can either act in combination or individually to cure some diseases and health problems. The entire plant is used for traditional medicinal purposes and this has resulted in considerable chemical analysis of most of the plant's active compounds which attributes to the medicinal properties. *S. cumini* is a healthy fruit with absolutely no trace of sucrose and is therefore, the only fruit with minimum calories. Glucose and fructose are the main source of sweeteners in the ripe fruits.

Different parts of *S. cumini* are used as an alternative medicine for the treatment of diabetes. Various experimental studies have been done in the last few decades to confirm the activity of the fruits, seeds and stem bark against diabetes mellitus[19]. One of the very common traditional uses of *S. cumini* is the powdered seed for controlling the blood sugar level in diabetic patients. The seeds are rich in proteins and calcium. The glycoside Jamboline is the main compound found in the seed which helps in controlling the blood sugar level by switching off the mechanism of starch converting to sugar when there is optimum amount of sugar already present in the blood.

The other common traditional medicinal properties includes its use for curing diarrhea, dysentery, obesity, enlarged spleen, mouth diseases etc. Various traditional medicine practitioners use the tree to cure diseases by using the powder, decoction, juice or paste of the different parts[20]. The mode of preparation and administration of these medicines varies among the different ethnic groups and countries. The leaves are used to make tea and are taken orally to treat diabetes in Brazil[21] and have been reported to have antihyperglycemic effects.

The effect of the fruit, seed and bark extracts has been studied *in vitro* and *in vivo* in many animal cell lines and animal models. **Table 2** lists some of the major health benefits of the different parts of the *S. cumini* plant. Among these the leaves and the bark have been reported as the most powerful parts of the tree as traditional medicines.

PROCESSED FOOD FROM THE FRUIT

Since all the parts of the *S. cumini* tree has proved to have medicinal properties against a number of diseases it has a high economic value for the application in the food processing industries. Different types of fruits have been used to prepare jam, jellies, syrups and ice creams since ages. Processing of food adds value to the fruits and also makes the seasonal fruits available for consumption throughout the year. According to the Ministry of Food Processing Industries (MoFPI), Government of India, the installed capacity of fruits and vegetables processing industry has increased from 1.1 million tonnes in January 1993 to 2.1 million tonnes in 2006. The processing of fruits and vegetables is estimated to be around 2.2% of the total production in the country.

The seed powder of *S. cumini* is used by the diabetic patients to control the blood sugar level naturally and is usually prepared at home by

drying the seeds and grinding it to a fine powder. Seed powder is also commercially available by a number of herbal product manufacturers in the Asian market. The fruit pulp is also used to prepare vinegar which is used to treat diabetes, digestion problems and as diuretic [22].

The fruit is also used to make wine during its short availability period. For the fermentation, *Saccharomyees cerevisiae* is used. Chowdhury and Ray have analyzed the Jamun wine and compared the properties with the red grape wine. The Jamun wine was reported to be high in tannins and a strong astringent taste with 6% alcohol [23]. Since processing of food may affect the availability of its nutrients, the stability of the processed food products is a major concern among the researchers. The various types of products made from *S. cumini* have been analyzed to check if the health benefits of the unprocessed fruits are still present in the processed products or not [24]. There are many commercial brands available in the Asian market especially in India which manufactures jam, jellies, ice cream and vinegar made from the *S. cumini* fruits (**Table 3**). These products are gaining popularity not only among the diabetics but also among the health conscious consumers due to its varied health promoting properties.

PLANT TISSUE CULTURE FOR CONTINUOUS SUPPLY OF PHYTOCHEMICALS

There is a very high anthocyanin content in *S. cumini* fruits which attributes to its antioxidant and free radical scavenging activity. These pigments can be a good source of natural food colourants for the food processing industries. But since the fruit is seasonal there is a limitation in the constant supply and hence an *in vitro* system needs to be established for the pigment production throughout the year. The forest trees are very difficult to mass propagate by tissue culture. There have been many efforts by various scientific groups to propagate this tree through tissue culture [25, 26].

The propagation of a majority of woody plants through vegetative methods is very difficult. Apart from this *S. cumini* suffers from very low seed viability and poor germination in its natural habitat [27]. The seed germinates when fresh but after two weeks at room temperature the seed is not viable [28]. Seed storage behaviour is recalcitrant; seeds germinate well when fresh, but viability is lost within 2 weeks of open storage at room temperature.

As high amounts polyphenols exude into the culture media from the explants, they turn brown shortly after inoculation. A stable pigmented callus and suspension cultures needs to be developed for the large scale production of the pigments from this tree *in vitro*. The pigment can be further checked for its stability to different physical parameters for its use as a natural colourant.

The tree has been successfully cloned by micropropagation technique using the nodal or meristem explants from the mature trees [29, 30, 31]. The use of *in vitro* grown seedlings as explants for micropropagation proves beneficial to control the browning of the culture media with phenolics.

CONCLUSION

S. cumini fruits are a very rich source of antioxidants and have numerous health benefits. The fruit pulp is used to prepare different processed food items. Some of these products are used just for the flavour and some used as medicine by the consumers. The astringent flavour is sometimes not preferred by some people but the bright purple colour of the fruit can be used as a natural food colorant. The various food processing parameters should be studied to make these fruits suitable candidates for use as colourants where the food items go through different types of physical and chemical processing in the food processing industries.

Although the *S. cumini* fruit proves to be a great nutraceutical due to its medicinal properties there is still need to have more scientific basis to use these products to cure diseases. Most of the studies are done *in vitro* or on animal models. The *in vivo* absorption of the same extract might vary in humans when consumed for the purpose of curing a health problem. There is still much research needed and there should be clinical trials along with the *in vitro* models to study the effect of these phytochemicals on human beings.

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