Scientific Inquiry and Review (SIR)
Volume 5, Issue 2, June 2021
ISSN (P): 2521-2427, ISSN (E): 2521-2435
Journal DOI: https://doi.org/10.32350/sir
Issue DOI: https://doi.org/10.32350/sir/52
Homepage: https://journals.umt.edu.pk/index.php/SIR/Home

Journal QR Code:

Article: ***Phytochemistry* of *Ziziphus mauritiana*: An Overview of its Nutritional and Pharmaceutical Potential**

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Online Published: June 2021

Article DOI: https://doi.org/10.32350/sir/52.01

QR Code:

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Citation: Butt SZ, Hussain S, Munawar KS. *Phytochemistry* of *Ziziphus mauritiana*: An overview of its nutritional and pharmaceutical potential. *Sci Inquiry Rev.* 2021;5(2):01–15.

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Indexing

A publication of the
School of Science, University of Management and Technology
Lahore, Pakistan

Phytochemistry of *Ziziphus mauritiana*: An Overview of its Nutritional and Pharmaceutical Potential

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Abstract

Ziziphus mauritiana, commonly known as the Ber plant in Pakistan, is a medium sized tropical fruit tree. It belongs to the family Rhamnaceae. The nutritional and pharmaceutical potential of Z. mauritiana is well reported. Different parts of this plant, such as leaves and fruits, have been thoroughly investigated for their chemical composition and pharmaceutical properties. It is a rich source of various minerals such as iron, zinc, copper, potassium, magnesium, and calcium. The edible parts of this plant are rich in ascorbic acid, vitamin A, and vitamin B complex. The fruit provides 1516-1575 kJ of energy per 100 g of fruit. Many scientific studies have claimed it is a potent antioxidant and antimicrobial agent. It shows excellent H_2O_2 scavenging activities. These properties are attributable to its complex chemical components such as flavonoids, alkaloids, and terpenoids. Moreover, many phenolic compounds have been extracted from different parts of this plant. Multiple studies have reported that the plant parts display anticancer, anti-inflammatory, and anti-allergy properties. Besides, it has also been cited as a pharmaceutical agent in wound healing, dysentery, asthma, tuberculosis, blood related diseases, diabetes and liver diseases. The therapeutic potential of this plant should be investigated against various antibiotic resistant bacteria in environmental and hospital settings. Such investigations will help to find a therapeutic solution for the aforementioned problem. Moreover, most of the investigations on this plant were carried out in vitro. In order to develop commercial pharmaceutical products, in vivo studies should be considered along with in vitro investigations.

Keywords: ber, nutritional, pharmaceutical phytochemicals, *Ziziphus mauritiana*

Introduction

Medicinal plants have been extensively investigated due to their nutritional [1, 2] and pharmaceutical value [3, 4]. The presence of carbohydrates, proteins, and fats in medicinal plants enables them to fulfil the human body's nutritional requirements. These components also play an important role in numerous morphological, physiological, and metabolic activities [5]. It has been reported that over 10 to 12% of the daily recommended dietary allowance (RDA) can be attained by consuming 100 grams of a nutritious plant [6]. Plants are also very important sources of medicine. Many new beneficial medicinal components and their phytochemical constituents (e.g., hypolipidemic, hypoglycemic, and antioxidants constituents) can be isolated from plants. A large number of plant derived (directly or indirectly) medicines are currently in use [7]. People have shared a common interest in the treatment of diseases through plant based medicines ever since the primitive age [8]. Modern day physicians and pharmacologists have also been gradually adopting the use of medicinal plants against diseases due to increasing awareness and evolving ideas in the field of medicine [7]. Many medicinal plants are being widely used as fruits and vegetables in Pakistan. Such medicinal plants are rich in carbohydrate content but are low in fats and proteins [6]. *Ziziphus mauritiana* (commonly known as the Ber plant in Pakistan) is a fruit tree that is well known due to its medicinal and nutritional benefits [9]. It has 40 species that are distributed in warm temperate and subtropical regions around the world [10]. The flesh of the fruit ranges from white to yellow white. During the ripening stage, its skin changes in color and turns red, and during the last stage, its skin shrivels up (Figure 1) [11]. The fruit of *Z. mauritiana* varies in shape and can be round, oblate or oval. The weight of the fruit varies from 3.8 g to 39.5 g, whereas the length of fruit ranges from 1.1 cm to 4.7cm [12].

Multiple studies have reported the nutritional and pharmaceutical value of this plant [13-15]. The current study provided a comprehensive overview of the chemical composition, antioxidant properties, and antimicrobial potential of *Z. mauritiana.* For this purpose, an overview of previously published literature extracted from Google Scholar, PubMed and Medline was conducted. The key words used to find the relevant literature were Ziziphus mauritiana, ber, *Indian jujube, and Chinese jujube.*

Figure 1. Fruits and leaves of *Ziziphus mauritiana* [11]

2. Chemical Composition

The leaves (Figure 1) of *Z. mauritiana* are chemically composed of proteins, amino acids, alkaloids, terpenoids, fibers, flavonoids, tannins, glycosides, and phenolic compounds [16]. IA study reported the GCMS analysis of *n*-hexane, chloroform and methanol extracts of *Z. mauritiana* leaves. . Methanolic extract of leaves showed the presence of diglycerol (0.30%), 2,3-dihydrobenzofuran (0.60%), 1,2-diacetate glycerol (1.44%), methyl palmitate (7.81%), palmitic acid (13.57%), linoleic acid methyl ester (5.98%), phytol (9.78%), methyl stearate (15.59%), lioleic acid (4.75%), α-linolenic acid (14.21%), stearic acid (1.94%), archidic acid methyl ester (1.60%), carbromal (0.76%), 3-methyl piperidine (0.48%), cyclobarbital (0.61%), squalene (12.09%), vitamin E (2.35%), and thymol TMS (1.26%). The chloroform extract contained uneicosane (4.79%), lauric acid (1.66%), myristic acid (2.80%), E-15-Heptadecenal (12.31%), methyl palmitate (2.83%), palmitic acid (38.55%), hentriaconate (3.25%), methyl stearate (2.31%), stearic acid (5.82%), α-nonadecylene (3.77%), bacchotricuneatin C (3.48%), α-tochopherol (10.01%), and vitamin E (5.41%). The *n*-hexane extract of *Z. mauritiana* leaves displayed the presence of myristic acid (0.73%), phytol acetate (1.02%), methyl palmitate (1.01%), palmitic acid (16.26%), linoleic acid, methyl ester (0.45%), phytol (2.52%), methyl stearate (0.53%), linoleic acid (1.37%), α-linolenic acid (26.45%), o-methyl delta-tochopherol (0.47%), octacosane (2.04%), squalene (12.83%), trans-geranylgeraniol (2.34%), 2,4-dimethyl Benzoquinoline (2.28%), α-tochopherol (3.92%), 4-chloro-2-trifluoromethylbenzoquinoline (1.74%), γ-sitosterol (2.72%), and 17-Hydroprogesterone (3.42%). Thus, α-linolenic

acid (26.45%), plamitic acid (38.55%), and methyl stearate (15.59%), were observed as major components in *n*-hexane, chloroform and methanol extracts of Z. mauritiana leaves, respectively. The chloroform extract possessed the highest amount of phenolics, while the flavanoids were found to be the chief constituents in methanol extract [9]. According to previous literature in this field, twelve compounds including betulinic aldehyde, palmitoleic acid, ceanothic acid, daucosterol-6'-octadecanoate, spinosin, beta-sitosterol, daucosterol-6'-octadecanoate, frangufoline, stearic acid, docosanoic acid, sucrose, and betulinic acid have been identified from seeds of *Z. mauritiana*. Silica column chromatography was used for the isolation of these constituents, whereas spectroscopic analysis and physico-chemical properties were used for structure elucidation [17]. In addition to the above mentioned substances, it was reported by previous researches that fruits of *Z. mauritiana* contain several bioactive phytochemicals such as phenolic acid and ascorbic acid [18]. The presence of saponin, terpenoids, flavanoid, tannins, and cyanogenic glycosides has also been reported in the pulp of *Z. mauritiana* [19, 20].

The highest contents of calorific value (411.61 kJ), carbohydrate (63.24%), fat (1.89%), and crude fiber (48.12%) were reported in the seed, while the moisture content (88.32%) was found to be the highest in the fruit of *Z. mauritiana*. The pH of the fruit and leaves was found to be 4.77 and 5.47, respectively. Another study was carried out to find the approximate composition of the *Z. mauritiana* plant, which reported that it was an excellent source of fiber, proteins, and carbohydrates. It was found that its fruits, leaves and seeds can act as a nutraceutical ingredient and may be utilized in pharmaceutical and food products due to its benefits [21].

3. Nutritional Value

The fruit of *Z. mauritiana* is enriched with nutrients. Its fruit contains more iron than an apple, and it is a well-known fact that iron is a necessary component for the transportation of oxygen in the body [22]. Additionally, researchers have shown that the edible parts of this fruit contains higher amount of nutrients and minerals, such as iron, zinc, calcium, sodium magnesium, and vitamin C etc. [23, 24]. Furthermore, studies indicate that 100 gram of pulp contains 70 to165 mg of ascorbic acid (vitamin C) [25], while its fruits are enriched with vitamin A and B complex [26]. Besides

the nutrients, fruits of *Z. mauritiana* provide 20.9 kcal per 100 gram of pulp [22]. Its fruit is an excellent source of proteins, carbohydrates, and micronutrients, such as vitamin C, zinc (Zn), iron (Fe), copper (Cu), phosphorus (P), sodium (Na), potassium (K), and calcium (Ca). In Zimbabwe, when the fruits of *Z. mauritiana* are in season, they become a major part of people's diet. The edible portion of Ber can either be sour and sweet. In 100 grams of Ber (sour and sweet), the weight of the dry contents of the edible portion ranges from 21.1 g to 24.1 g. The dry weight of 100 gram of edible portion contains crude fiber (4.9 g to 7.3 g), crude proteins (7.9 g to 8.7 g), fat contents (0.8 g to 1.5 g), and carbohydrate content (79.5 g to 83.2). The fruits of *Z. mauritiana* were found to be rich in vitamin C (15 mg to 43.8 mg per 100 g) and have energy value of 1516-1575 kJ per 100 g. Table 1 shows a compilation of the concentrations of different nutrients present in *Z. mauritiana* that is reported by previous studies [16, 24].

Table 1. Concentration of Different Nutrients in 100 Grams of Fruit of *Ziziphus. mauritiana*

Nutrients	Conc. in mg /100 g of fruit	Nutrients	Conc. in mg /100 g of fruit
Calcium (Ca)	160-254	Iron (Fe)	2.1-4.3
Potassium (K)	1865-2441	Zinc (Zn)	0.6-0.9
Magnesium (Mg)	83-150	Copper (Cu)	0.7
Sodium (Na)	185-223	Manganese (Mn)	1.6
Phosphorus (P)	87-148		

4. Pharmaceutical Importance

Plants are sources of many natural drugs and are useful for the treatment of chronic diseases [14]. It is estimated that herbal medicines and their formulated drugs contribute to the development of more than 60% of clinical drugs in the world [27]. It was reported by WHO that 80% of the world population is dependent on the drugs derived from plants [28]. In a like manner, *Z. mauritiana* has become distinctly reknown for the treatment

of many diseases. For example, its leaves are used for treatment of tuberculosis and blood related diseases. Additionally, the juice of its leaf along with buffalo's milk is considered effective therapy against small pox. The paste of its leaves is used on wounds to get rid of burning sensations. Conventionally, a mixture of fresh *Z. mauritiana* leaves and cumin is given to patients to treat urinary tract infection. Furthermore, the root of this plant is mixed with cow's milk and is used to cure dysentery. Patients are advised by conventional therapists to keep a fresh root of *Z. mauritiana* in their mouth to get rid of hoarseness of throat [29-31]. Almost all parts of this plant show potential for treatment of numerous diseases. For example, its roots and stems are traditionally used for the treatment of dysentery and diarrhea. The root bark of this plant also effectively function as an analgesic, anti-inflammatory and anti-allergic agent [32].

Z. mauritiana is also very useful in the treatment of pregnancy related problems, such as nausea, vomiting, and abdominal pains. Diseases like asthma, fever, and liver issues can also be treated with *Z. mauritiana* leaves [33]. It was also experimentally proven that extracts of different parts of *Z. mauritiana* possess high potential against cancer, inflammation, and diabetes [34-37]

It was also found that *Z. mauritiana* was traditionally used for culinary uses, medicinal purposes, health maintenance, and for the improvement of digestion [38-42]. Antibacterial, antioxidant and anti-inflammatory activities were found to be some of the medicinal properties of this plant [29, 30].

4.1. Antimicrobial Activity

Through the analysis of the extracts of *Z. mauritiana* leaves, it was found that it shows antimicrobial activity against different microorganisms. Many antimicrobial components found in *Z. mauritiana* plant can be used for the therapy of microbial infections [11, 20, 43-45]. For example, the methanolic and ethanolic extracts of *Z. mauritiana* leaves show a broad range of antimicrobial activities against different bacteria, such as *Staphylococcus aureus, Escherichia coli, Streptococcus pyogenes and Klebsiella pnemoniae*. [20, 43]

It was found that a wide range of phytochemicals is present in the pulp of fruit of *Z. mauritiana*, due to which it (crude and fractionated extracts) shows antimicrobial potential. Some studies on *Z. mauritiana* revealed the occurrence of secondary metabolites, such as tannins, terpenoids, and flavonoids, having antibacterial potential [11, 44, 45]. Various researchers also reported that *Z. mauritiana* can be used as an anti-diabetic neuroprotective and hepatoprotective agent [46, 47].

4.2. Antioxidant Potential

Cancer is one of the many causes of the increasing mortality rate in the world. Many therapeutic methods have been invented for the treatment of cancer. These methods include treatments such as chemotherapy, which has many adverse effects on the healthy tissues in a body. Therefore, it has become the need of the current era to develop alternate treatments for such life threatening diseases. Plant extracts show many interesting results in this regard [48]. Oxidative stress is the condition in which oxidants are increased in number, which disturbs the natural cellular reactions of a body. If this condition is prolonged, then it may result in different diseases (like cancer) [49, 50]. This condition is cured through the use of antioxidants. Antioxidants are those agents that have the ability to inhibit, delay, or interfere in the aerobic reactions by neutralizing free radicals (by donating electron or atom, quenching oxygen in triplet, and singlet form and chelating metals). They also play an important role in increasing the shelf-life period of food. They also aid in the treatment of ailments such as cancer, aging, and inflammation [51]. They are naturally occurring compounds (phytochemicals) in plants that possess the potential to inhibit numerous diseases due to their antioxidant effect [52].

Several investigations report the antioxidant potential of *Z. mauritiana* [53]. In one such study, it was reported that the good antioxidant and H_2O_2 scavenging activities can be owed to the presence of a high amount of total proteins, reducing sugars, flavonoids, ascorbic acid contents, β-carotene, polyphenols, tannins, and DPPH free radicals [54, 55]. It was also reported by researchers that there are about eight different flavonoids in fruits, leaves, and seeds of *Z. mauritiana* [56]. Researchers also stated that

phenolic acids are present in this plant in free/conjugated from, along with carbohydrates and other biomolecules [57].

Previous researchers indicated that the crude methanolic extract of *Z. mauritiana* leaves is rich in phytochemical constituents, which have significant antioxidant and antimicrobial activities. The isolation and purification of these bioactive phytochemical constituents may further produce more potent antioxidants [55]. It was reported that methanolic seed extracts of this plant are markedly effective against cancerous cells. Furthermore, ethanolic extracts of seed were shown to have the ability to inhibit the proliferation of HL60 cells [58].

5. Conclusions

In many previously conducted in vitro studies, the methanolic and ethanolic extracts of *Z. mauritiana* have shown promising antimicrobial properties against many gram positive and gram negative bacteria. Therefore, it is recommended to evaluate its potential via in vivo studies for developing novel pharmaceutical products that are effective anti-bacterial agents. For example, previous studies have already reported its antibacterial activity against wild *S. aureus and K. pneumoniae.* Thus, it is suggested to evaluate its antibacterial potential against antibiotic resistant strains, such as methicillin resistant *S. aureus*. These investigations will aid in the discovery of new and effective therapeutic agents, which could treat various illnesses caused by antibiotic resistant organisms. Furthermore, previous studies have used whole crude extract of fruit, leaves and barks to acquire their findings. Therefore, it is recommended that future studies should focus on finding the exact chemical component within the extract that is responsible for the specified biological response.

Conflict of Interest

The authors declare no conflict of interest.

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