



REVIEW ARTICLE

# The multifaceted utility of mulberry (*Morus* spp.): A comprehensive review on uses of its different parts

R Moulidharshan<sup>1</sup>, P Priyadharshini<sup>1\*</sup>, R Shanmugam<sup>2</sup>, M Tilak<sup>3</sup>, P Radha<sup>4</sup>, V Ulaganathan<sup>1</sup>, R Nandha Kumar<sup>1</sup> & V Vasanth<sup>1</sup>

<sup>1</sup>Department of Sericulture, Forestry College & Research Institute, Tamil Nadu Agricultural University, Mettupalayam 641 301, Tamil Nadu, India

<sup>2</sup>Indian Council of Agricultural Research - Krishi Vigyan Kendra, Tamil Nadu Agricultural University, Ooty 643 002, Tamil Nadu, India

<sup>3</sup>Department of Agroforestry, Forestry College & Research Institute, Tamil Nadu Agricultural University, Mettupalayam 641 301, Tamil Nadu, India

<sup>4</sup>Department of Forest Biology and Tree Improvement, Forestry College & Research Institute, Tamil Nadu Agricultural University, Mettupalayam 641 301, Tamil Nadu, India

\*Correspondence email - [priyadharshini.p@tnau.ac.in](mailto:priyadharshini.p@tnau.ac.in)

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## Abstract

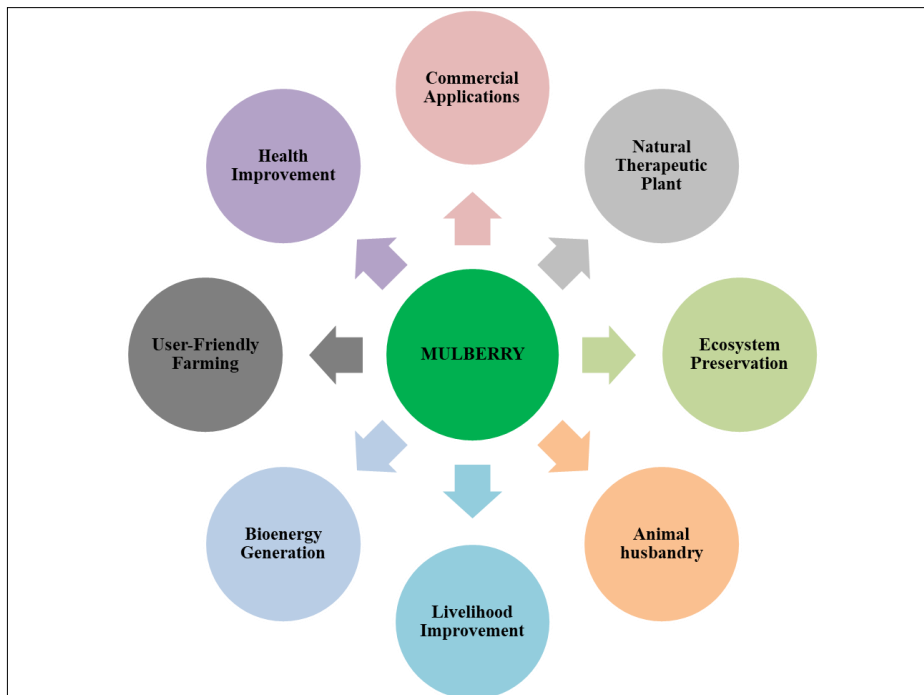
Sericulture has become a vital rural sector in India, making the country the second largest silk producer in the world behind China. This sector is separated into farming (pre-cocoon sector) and industrial sector (post-cocoon sector). Here, farming involves the cultivation of mulberry plants and the rearing of silkworms, while the industrial sector includes reeling, knitting, twisting, dyeing, printing and finishing. The mulberry, which is a fast-growing woody perennial from the genus *Morus*, serves as vital for sericulture. The important species that come under the genus *Morus* include *Morus indica*, *Morus alba* and others. The silkworm *Bombyx mori*, which is a host-specific insect, comes under the order Lepidoptera and feeds exclusively on mulberry leaves to produce protective cocoons, attracted by chemicals like citral and betasitosterol, which are present in the mulberry plant. Apart from sericulture, mulberry plants serve nutritional and medicinal benefits, high in vitamins, minerals and organic compounds, leading to their exploitation in food, pharmaceutical, cosmetic and healthcare industries. Generally, every plant has different parts like leaves, bark, roots and fruits. Here in mulberry, these parts possess a variety of properties such as antioxidant, anti-inflammatory, anti-cancer, anti-diabetic, anti-bacterial and so on. This paper explores diverse uses of mulberry plants.

**Keywords:** medicinal; mulberry; pharmaceuticals; sericulture; therapeutic; various use

## Introduction

India is the world's second largest producer of silk, after China. As a result, it shows sericulture's potential as a rural sector in India (1). The two sectors of sericulture are farming and industry. Growing food plants for silkworms and raising them to lay eggs and produce cocoons are both part of the farming. The industry sector is made up of reeling, knitting, twisting, dyeing, printing and finishing (2). The genus *Morus*, which includes more than 15 species of deciduous plants, includes the mulberry, a woody perennial plant with a quick growth rate. Some of the most common ones include *Morus alba*, *M. indica*, *M. nigra*, *M. rubra*, *M. australis*, *M. atropurpurea*, *M. cathayana*, *M. notabilis* and *M. mesozygia* (3). In India, the two species of mulberry, *M. laevigata* and *M. serrata*, grow wild; the former is found all over the country, including the Andaman and Nicobar islands, while the latter is limited to the country's northwest. The two cultivated varieties that were noted were *Morus indica* and *Morus alba* (4). The *Bombyx mori* is a host-specific insect that exclusively consumes mulberry (*Morus* spp.) leaves to form a

cocoon that serves as a protective coating. *Bombyx mori* larvae are attracted to the leaves by citral, linalyl acetate, linalool, terpinyl acetate and hexenol, with the first three being the most effective. The primary component that causes *B. mori* to bite mulberry leaf during feeding is betasitosterol, which also contains other sterols and a water-soluble material (5). In addition to feed for silkworm, mulberry has various additional uses. By using the physiologically active pharmacokinetic chemicals present in the leaf, stem, fruits and root sections of the plant, mulberries are also utilized as a medicinal herb to prolong and improve human life. Industrialists are interested in the potential benefits of further industrial mulberry exploitation through the production of diverse products for the food, cosmetic, pharmaceutical and healthcare industries (6). The role of mulberry as a multipurpose plant is shown in Fig. 1. Mulberries are a great source of iron, riboflavin, vitamin C, vitamin K, potassium, phosphorus and calcium, among other essential minerals and are said to have numerous nutritional advantages and therapeutic effects. In addition, they have a high content of dietary fibre and a variety of



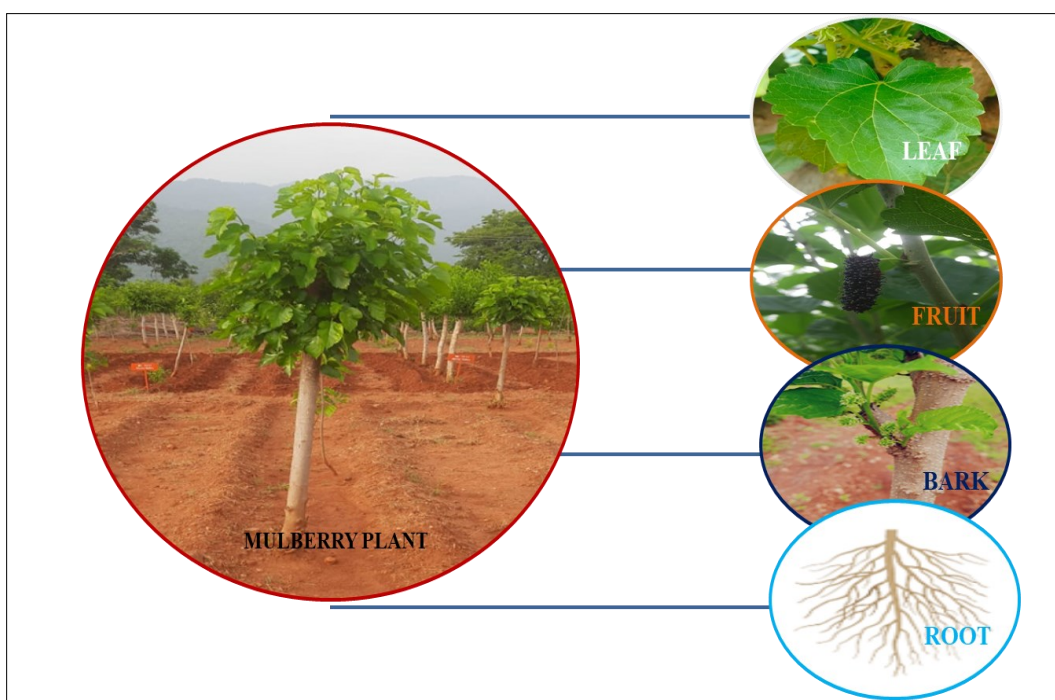
**Fig. 1.** Role of mulberry as a multipurpose plant.

organic substances, such as lutein, anthocyanins, zeaxanthin, resveratrol, phytonutrients and other polyphenolic compounds (7). The different parts of the mulberry plant include leaves, bark, roots and fruits which are shown in Fig. 2. Here, apart from silkworm feeding, the various uses of mulberry plant parts are discussed.

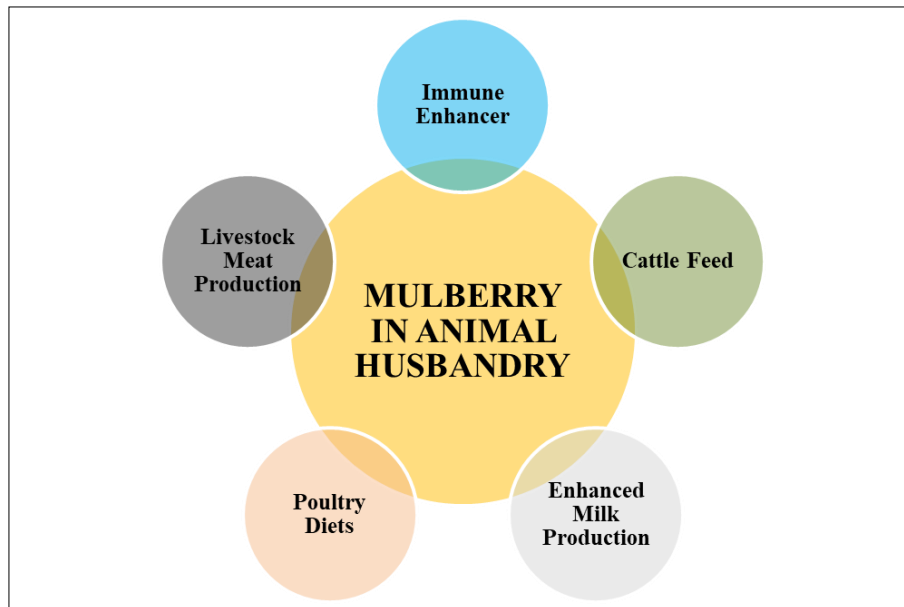
**Mulberry leaves**

Mulberry leaves can be utilized as an additional source of protein for ruminants due to their high protein content, low fibre level and excellent digestibility (8). Study has reported that, when mulberry leaves are fed to sheep on a mixed fodder and concentrated diet, the feed has high perceived digestion due to the high crude protein content (approximately 20 % of dry matter) as well as minimal crude fibre content (about 12 % of dry matter) (9). Mulberry leaf

meal complements concentrate mixes due to its high crude protein, good Ca to P ratio, potential rate of digestion, good degree of digestion and encouraging digestion (10). Mulberry leaves are less expensive than expensive protein sources like fish meal and soybean meal, they would be valuable alternatives for the chicken sector when it comes to feed prices. According to some studies, the diet made of mulberry fed to chickens, adds up to 10 % more benefit without hurting the birds’ performance (11). The significance of mulberry in animal husbandry is shown in Fig. 3. With a significant proximate and mineral content and a small number of anti-nutrients as compared to the control, the chapathi mix made with 5 % mulberry leaves has been positively received (12). The results of a study on mulberry leaf feed for rabbits indicate that mulberry leaves can take the place of lucerne hay in complete rabbit feed (15



**Fig. 2.** Various parts of mulberry plant.



**Fig. 3.** Significance of mulberry in animal husbandry.

% of diet). Even at larger dosages, between 30 % and 45 % of the diet, full feed made of mulberry leaves produced encouraging outcomes (13). Rutin was powdered after being extracted from mulberry leaves and utilized as a food component in a variety of dishes rutin was powdered after being extracted from mulberry leaves and utilized as a food component in a variety of dishes, including beverages, confectionery, noodles and frozen foods (14). The contents of the mulberry leaf yoghurt, which was made from mulberry leaves, were 86.36 % moisture, 4.13 % carbohydrate, 4.87 % protein, 3.79 % fat and 0.85 % ash (15). For every 100 g of dried mulberry powder, the nutritional value of mulberry leaves includes 19 g of protein, 581 mg of calcium, 21 mg of iron, 9.21 µg of vitamin A and 18 mg of vitamin C. There were the major phytochemicals, including flavonoids, alkaloids, glycosides, phenols and tannins. Mulberry leaves were effective in combating bacterial activity in their antibacterial property (16). The isolated flavonoids from *M. alba* including various mulberry leaf extracts, isoquercetin and rutin, were evaluated for their anticancer effects against a stomach cancer cell line. These compounds were administered both individually and in combination with cisplatin to assess their potential synergistic effects (17).

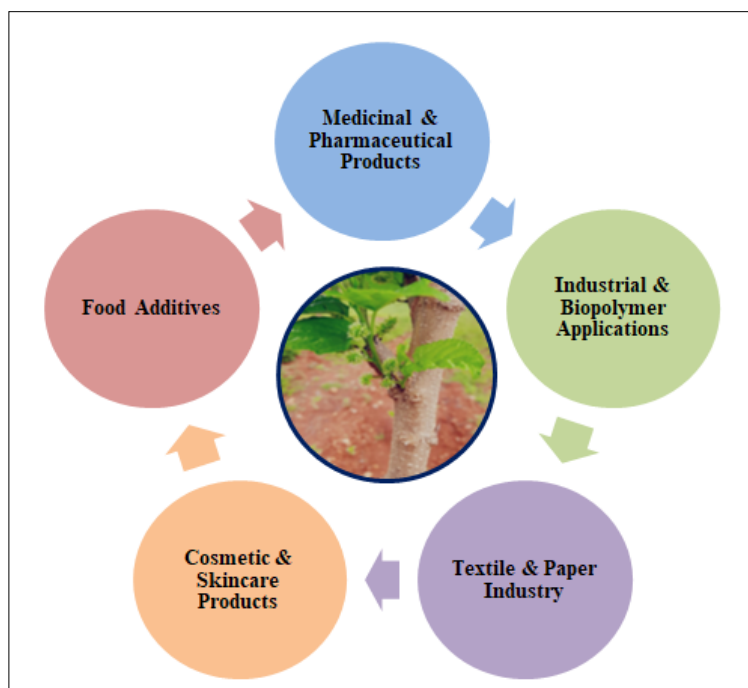
#### Mulberry bark

The mulberry's branch bark ethanol extract's (BBEE) biological activity was studied. The analysis of the active ingredients revealed that the main components of the ethanol extract are flavonoids, phenols and saccharides. The BBEE might efficiently reduce postprandial hyperglycemia as a new inhibitor of  $\alpha$ -glucosidase activity for the treatment of diabetes (18). On the whole, oral treatment of mulberry branch bark powder efficiently maintained the usual state of glucose metabolism and regulated the release of insulin in mice. This may be achieved by enhancing antioxidant capacity, preventing pancreatic cell death and healing liver and pancreas damage (19). There are several applications for mulberry bark fibre micro composite in the automotive, textile and

packaging industries. Therefore, it can substitute current materials as a biopolymer formed from the bark of the Indian mulberry plant in various polymer applications according to its performance (20). Mulberry stems have been utilized as reinforcement in polypropylene composites for usage in automobiles, furniture and green buildings (21). Glucose, rhamnose, arabinose, galactose, xylose, mannose and galacturonic acid were all present in the crude polysaccharide-rich mulberry branches. Despite the presence of flavonoids and phenols in the bark extract, the polysaccharides may still have an antioxidant effect (22). When compared to other fibres, the level of cellulose of the stem of *M. alba* stem fibre was found to be adequate and produced better results, according to an analysis of the chemical composition. The considerable physical, chemical and thermal qualities of *M. alba* stem fibre make it a better material to replace synthetic fibres, according to the characterization data (23). The phenolic components of ethanolic extracts of mulberry twig were maclurin, rutin, isoquercitrin, resveratrol and morin. These bioactive components, which function as tyrosinase inhibitors and antioxidants, may enhance the protective benefits of ethanolic extracts of mulberry twigs (EEMT). Ultimately, the results revealed that EEMT could serve as a tyrosinase inhibitor and natural antioxidant (24). The inner layer of mulberry branch bark contains cellulose pulp that can be added to paper pulp up to 30 % of the way to make paper (25). Pectin with varying degrees of esterification may be found in the bark of mulberry branches (26). Cellulose whiskers were extracted from the branch bark of *M. alba* L. These whiskers have potential applications as additives in the pharmaceutical and optical industries, as well as reinforcement components in composite materials (27). The diverse uses of mulberry bark is shown in Fig. 4.

#### Mulberry root

Mulberry root bark serves as one of the potential sources of antioxidant materials that can be used to help with oxidative stress (28). Asian traditional medicine has utilized *M. alba* as an anthelmintic, anti-inflammatory, anti-



**Fig. 4.** Diverse uses of mulberry bark.

asthmatic and whitening ingredient in cosmetics. The main active ingredient found in the root bark of *M. alba* is mulberroside A (29). The steam-treated mulberry root bark water extract is a promising source of phytochemicals with great biological activity. It can be used to strengthen a variety of food and medicinal products (30). The study found that the bark of mulberry roots has anti-cancer and anti-inflammatory properties (31). The ingestible Chinese herbal remedy, which is made up of white mulberry root bark (WMR), has the property to cure asthma, nephritis and inflammation (32). The presence of the increased concentration of active components such as p-hydroxybenzoic acid and chlorogenic acid, which proves that the mulberry root cortical extract shows stronger antioxidant and whitening properties (33). Oxyresveratrol from *M. alba* roots can be effectively extracted via microwave-assisted micellar extraction. The skin penetration of the solid lipid nanoparticles lotion was good and the solid lipid nanoparticles containing 2.5 % glyceryl monostearate demonstrated the best qualities (34). The 70 % alcohol extract of *M. alba* may function as a strong antioxidant and hypocholesterolemic supplement by preventing the production of lipid peroxides and LDL atherogenic alterations in hypercholesterolemic rats (35). Methanolic extract of the root bark of *M. alba* was found to greatly diminish the fibrotic and inflammatory alterations in histological investigations. In general, this study highlighted the potential of mulberry root bark extract as a natural anti-inflammatory drug, especially in the context of pancreatitis. Cudraflavone B is one of the phytonutrients that may contribute to the anti-inflammatory properties of *M. alba* root bark extract (36). Cultured *M. alba* hairy roots may contain tyrosinase inhibitors that could be used as a future skin-whitening component (37).

### Mulberry fruit

Mulberry fruits are visually appealing, have a distinct flavor and have bioactive substances that have been linked to

several health advantages and supported by scientific research (38). The fruit jam, which is enriched with mulberry, is a good source of antioxidant properties such as rutin, anthocyanins and quercetin and offers health-developing properties. It enhanced the nutritive value of fruit jam, like energy, carbohydrates, fat and dietary fibres. In addition, it also completely substituted refined sugar and preservatives (39). The natural substance morin, which is extracted from mulberry fruits, may be helpful in managing antibacterial and antioxidant therapies (40). It was determined that the jeolpyeon made with 4 % mulberry fruit powder added to rice flour had the best overall acceptance and textural attributes (41). In terms of color, flavor, texture and general appeal, the Oddi jelly with 2 % mulberry fruit powder has the best qualities overall (42). The mulberry fruit is abundant in anthocyanin, a biologically active compound, which contributes to its global recognition. The schematic representation of the Mulberry fruit's biological function has been shown in Fig. 5. Here the study investigated the physico-chemical characteristics of Thai mulberry fruit powder (MFP) and its potential application as a component in the preparation of jelly that is rich in anthocyanin (43). In dyslipidemic patients, the anthocyanin improved the sensitivity to insulin and postprandial blood antioxidant-oxidative stress response while reducing LDL (low-density lipoproteins), blood total cholesterol and inflammation (44). The alcoholic beverages prepared from mulberry fruit have a fine taste. In addition, it also possesses nutritional and medicinal value, which further makes the product's potential for market popularity (45). Salad dressing made from powdered mulberry fruit, with 0.5 % mulberry fruit powder (MFP) producing the most stable emulsion and a much higher viscosity during storage (46). The black mulberry fruit is used to make RTS (ready to serve) drinks (47). Mulberry fruits are strong in antioxidant activity and have valuable sensory and nutritional properties, making them a desirable addition to muesli. Oat flakes, granulated bran, linseed and white mulberry fruits mixed with a muesli base may be an

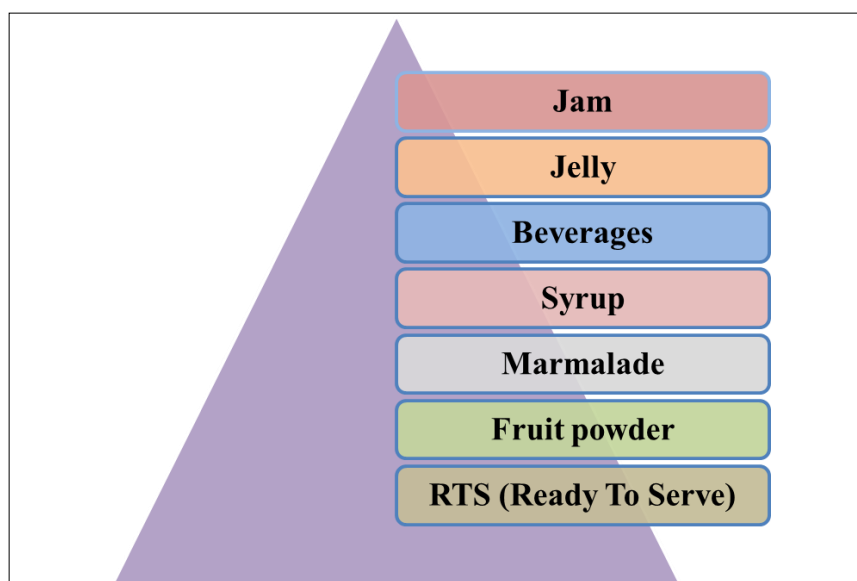


**Fig. 5.** Schematic representation of the mulberry fruit's biological function.

important part of a diet (48). The people who are living in Tenerife, La Gomera, La Palma, El Hierro and Lanzarote harvest mulberry fruits and make their own homemade beverages. These beverages are used for medicinal purposes. Many authors have stated that the mixture of black mulberry and water can help control type II diabetes mellitus. Additionally, this fruit has been used to cure the swelling of the mouth, tongue and throat (49). Crucially, luteolin, luteolin-7-O-glucoside, (-)-epiafzelechin, eriodictyol, kaempferol and quercetin - among the flavonoids that are plentiful in mulberry fruit were found to be the distinct biochemical markers during the fermentation and ripening processes of black mulberry berry wine (50). The various food products from mulberry fruit is shown in Fig. 6.

### Conclusion

In conclusion, employing every part of the mulberry tree to its fullest potential shows a comprehensive approach to resource management and sustainability. The main source of nourishment for silkworms is the leaves of the mulberry tree, which facilitates the process of producing silk, an important business for millennia. Mulberry leaves also contribute to food security and animal health because they are high in nutrients and have been used in traditional medicine and as cattle feed. The mulberry tree yields delicious and adaptable fruits that can be utilized in drinks, jams and culinary preparations. Their inherent dyeing ability also enhances the value of crafts and fabrics. Mulberry tree wood is also highly valued for its fine texture and longevity, which make it ideal for furniture, cutlery and musical instruments. Utilizing the



**Fig. 6.** Various food products from mulberry fruit.

mulberry tree to the fullest extent can help us limit waste, lessen our impact on the environment and encourage sustainable behaviors. This includes using its leaves, fruits and wood. This all-encompassing strategy promotes a more resilient and balanced ecology for next generations by honoring the interdependence of human innovation and the natural world.

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## Authors' contributions

PP helped in choosing the review topic and its outline. RS, MT, PR, VU, RNK and VV participated in giving ideas related to the topic and drafted the manuscript. All authors read and approved the final manuscript.

## Compliance with ethical standards

**Conflict of interest:** Authors do not have any conflict of interests to declare.

**Ethical issues:** None

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