A mini-review of distribution, growth environment and nutrient composition from Scorias spongiosa (Bamboo Bird's Nest)

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Abstract. Scorias spongiosa is an edible fungus. The fruiting bodies of Scorias spongiosa contain various chemical composition such as polysaccharides, steroids which have many pharmacological effects, such as anti-oxidation, antitumor and bacteriostatic. In this review, the distribution, growth environment and nutrient composition of Scorias spongiosa were summarized systematically, and the development prospect of Scorias spongiosa (Bamboo Bird's Nest) was prospected.

1. Introduction
Scorias spongiosa, also known as Bamboo bird's nest fungus in China, which is grown on the honeydew secreted by aphids. The spores of sooty mould are attached to the honeydew, and the mycelium and fruiting bodies are grown. The fruiting body is large in size, and the aging of fruiting bodies will form blocks and carbonate the rod, which will affecting plant photosynthesis cause kill the bamboo. S. spongiosa is an edible fungus in China, which showed a colloidal coral with a light yellow or black color [1]. At present, the S. spongiosa has not been cultivated artificially on a large scale, and all the products developed on the market are wild resources, so it has great development prospects [2]. In this mini-review, we systematically summarize the research progress of S. spongiosa in recent years on the basis of domestic and foreign literatures about distribution, growth environment, nutrient composition and active substance, so as to provide reference for better utilization and development of S. spongiosa in the future.

2. Species and Distribution
S. spongiosa belongs to the order Capnodiales, family Capnodiaceae and the genus Scorias Fr., (1825) in taxonomy. At present, there are 12 species of Scorias Fr., (1825), but the exact species and number are not clear. S. spongiosa is a new record of bamboo sooty moids identified by Professor He et al in 2011 through pure culture test and ITS sequence analysis. It is mainly distributed in Yibin, Mianyang, Leshan, Deyang, Guizhou, Jiangsu and Zhejiang in China. Some scholars have found that in the United States, Canada, Thailand, India, Pakistan and other places also have distribution. [3, 4]. Pan et al found
through the ITS molecular identification that the strain of *S. spongiosa* collected in Hangzhou, Zhejiang Province is the same strain as the strain isolated from He[5].

3. Biological characteristics

3.1. Morphological character

The fruiting body of *S. spongiosa* is coral-like and relatively large, with the maximum fruiting body reach up to 20 cm, and the weight of fresh fruit body is about 300-1000g, which is composed of about 5-8 large branches, and a saclike dark conidium with long beak is formed on the top of the surface of the branches[3]. Liu et al studied that there is difference in color and morphology of *S. spongiosa* in different growth stages. In the early stage of growth, it was white and transparent, with small bulges on the main stem. In the middle stage, the color of the base will gradually become black, and the bulges formed new branches. In the later stage, the fruiting bodies were completely black, and no new bulges were growing. And the moisture content of *S. spongiosa* did not change much during the whole growth stage [6].

Some of the *S. spongiosa* in the growth process are basal enlargement, some are mid-upper enlargement, or both forms, and it is speculated that the difference in morphological characteristics may be related to changes in climatic conditions [1].

3.2. Growing environment

*S. spongiosa* generally occurs in bamboo forests affected by bamboo aphid in China, and symbiosis with bamboo forests and aphids, but in the United States and Canada, the main growth is in the Quercus palustris, Tilia Americana and Acer spp. *S. spongiosa* generally grows in summer and autumn, and there is more rain in July to August in summer, and the appropriate temperature is 16°C to 32°C in wet season from September to November. Therefore, the *S. spongiosa* may belong to the wet-type edible fungus. During the artificial culture of this strain, it was found that spores of *S. spongiosa* fruiting bodies were easy to grow after inoculation on PDA medium. The spores were germinated at a temperature of 15°C to 30°C. When the total germination rate reached the highest, the optimum germination temperature was 21°C, the optimum PH7.0, the optimum nitrogen source was ammonium chloride, the optimum carbon source was soluble starch, and the total germination rate could reach 70%. When the temperature was 27°C, the growth rate of mycelia was the fastest, with the optimal PH7.0. The optimal carbon source for growth was maltose, and the optimal nitrogen source was peptone. Among them, the temperature factor had a greater influence on the spore germination and mycelium growth than the PH value [8].

![Figure 1](image_url)

*Figure 1.* The comparison chart of *Scorias spongiosa* from domestic and abroad. A: Scorias spongiosa grows in the broadleaf forest of Washington (Creator: Katja Schulz); B: Scorias spongiosa grows in the broadleaf forest of Pittsburgh (Creator: Katja Schulz); C: Scorias spongiosa grows in the bamboo forests of Sichuan province; D: Scorias spongiosa grows in the bamboo forests of Sichuan province.
3.3. Culture of fruiting bodies
The morphological development process under artificial culture condition is as follows [7]:

![Diagram of fruiting body development process](image)

**Figure 2.** The developmental process of the fruiting bodies of *Scorias spongiosa*

3.4. Nutrient composition
At the early stage of growth, *S. spongiosa* is golden yellow in color, crisp and delicious, and more nutrients. It is a kind of edible fungus with rich nutrients. It was found that every 100g of *S. spongiosa* contained 38.4g of total sugar, 7.4g of crude polysaccharide, 6.8g of crude fiber, 12.8g of crude protein, 4.1g of crude fat, 9.3g of ash and 12.4g of water, and the content of total sugar and protein was significantly higher than that of *Auricularia auricular*, *Pleuritic ostreatus*, *Flammulina volutes* and *Lentinus edodes*.

The essential amino acid content is as follows: threonine content 480mg, valine 500mg, methionine 100mg, isoleucine 280mg, leucine 460mg, phenylalanine 230mg, lysine 360mg, histidine 480mg, and a lot of other types of non-essential amino acids, the ratio of essential amino acids to non-essential amino acids is 0.71, in line with FAO/WHO requirements for ideal proteins [2]. *S. spongiosa* is also rich in Ca, K, Mg, Na and other large amounts of elements as well as B, Cr, Fe, Zn, Se, Cu, Mn and other trace elements, the specific content of which is shown in Table 1. Pan et al have also found that the *S. spongiosa* contain mineral elements such as Cu, Mn, Zn, Fe, Ca, and the contents of heavy metals Hg, Pb, Cd and as are in line with the National Food Safety Standard [5]. Through experiments, liu ling et al found that there were differences in the heavy metal content in the meliolas collected from leshan and yibin areas, among which the heavy metal content of melias collected from yibin areas met the standards, the Pb content of melias collected from leshan areas exceeded the standards, and the As, Cd and Hg content met the food safety standards. The Pb content of heavy metals in Leshan area has a certain relationship with the poor growth environment. It also indicated that the heavy metal content of the *S. spongiosa* is related to its growth environment [10].

![Table 1](image)

**Table 1.** Contents of mineral element components of *Scorias spongiosa* fruiting body [2]

| Macroelement | Content(mg/100g) | Trace element | Content(mg/100g) | Trace element | Content(mg/100g) |
|--------------|------------------|---------------|------------------|---------------|------------------|
| K            | 3471.06          | B             | 18.77            | Cu            | 0.0704           |
| Na           | 90.417           | Fe            | 10.091           | Cr            | 0.636            |
| Ca           | 379.59           | Zn            | 2.419            | Se            | 0.0248           |
| Mg           | 152.338          | Mn            | 1.003            |               |                  |

3.5. Biological activities
Through a large number of studies by researchers at home and abroad, it has been found that edible fungi are rich in essential amino acids, various minerals, trace elements, vitamins and other nutrients, as
well as low energy, little lipid, and a lot of polysaccharides, steroids, terpenes and other compounds [9,11,12]. *S. spongiosa* as a fungus, containing a lot of active substances. Huang et al identified certain ergo sterol in *S. spongiosa* by HPLC, and ergo sterol had similar structure to vitamin D, as well as antibacterial and anti-inflammatory effects [13]. Feng et al extracted polysaccharides from *S. spongiosa* by water extraction and alcohol precipitation method, and determined the content of polysaccharides to be 3.72%. Moreover, *S. spongiosa* polysaccharides had certain antioxidant activity to DPPH. Meanwhile, the activity of catalase and superoxide gasification enzyme of *S. spongiosa* increased first and then decreased with the extension of culture time. The experimental results showed that the most vigorous growth and metabolism stage was from the 10th day to the 12th day [14]. Yan studied whether several surfactants and organic solvents can promote the extraction of extracellular polysaccharides from *S. spongiosa*. The results showed that Tween 80 and chloroform were used to extract extracellular polysaccharides from *S. spongiosa* enhancement. GC-MS analysis showed that the extracted extracellular polysaccharide was mainly composed of glucose and mannose. The relative molecular mass of the polysaccharide was determined by SEC-MALLS. The relative molecular mass of the polysaccharide extracted from Tween 80, chloroform and the control group was 1.628 x 106, 1.606 x 106 and 1.066 x 106 g/mol, respectively. The three extracellular polysaccharides of *S. spongiosa* showed cytotoxic activity against human hepatoma (Hep-G2) and human osteosarcoma (MG-63) cells, and the exopolysaccharide extracted by chloroform inhibited cancer cells better [15]. Yuan extracted the ethanol extracts of *S. spongiosa* and five other fungi by ethanol extraction, which had certain inhibitory ability on four kinds of plant pathogenic bacteria, namely *Ralstonia solanacearum*, *Xanthomonas oryzae*, *Erwinia carotovora* and *Xanthomonas citri*. However, it has no inhibitory effect on several pathogenic fungi such as *Valsa mali* Miyabe et Yamade, *Sphaceloma ampelinum*, *Alternaria alternaria* fsp mali, *Fusarium oxysporum* f. sp. *vasinfectum* (Atk.) Snyder & Handson, *Pythium ultimum* Trow, indicating that ethanol extract of *S. spongiosa* has certain difference in antibacterial effect on different types of pathogens [16]. Yuan by *S. spongiosa* ethanol extract on human esophageal cancer cells (Ecal09, TE a 1), human lung adenocarcinoma cells (PC a 9), human colon cancer cells (HT29 HCT116) breast cancer cells (MCF 7, MDA - MB a 231), human liver cancer cells (HepG2, SMMC 7721) and human leukemia cells (MV4-11, H1975), and other 11 kinds of malignant cancer cells for anti-tumor research, the results showed that the ethanol extract of *S. spongiosa* have strong anti-tumor activity against Ecal09, MDA-MB-231, MV4-1 and SMMC-7721[17].

Through the bread baking experiment, rheological experiment, Peng studied that the bread with the addition of *S. spongiosa* fruiting bodies powder increased the extensibility by 0.02cm/min, the water content by 0.03%, the specific ductility by 0.2mm/h, and the content of protein increased 0.7%, the ash was reduced by 0.02%, and the bread with the addition of *S. spongiosa* was more nutrients than the one without added [18].

4. Conclusions and future perspectives

As a kind of edible fungus, *S. spongiosa* has been gradually paid attention by researchers in recent years. It contains more nutrients, such as amino acids, proteins, mineral elements, pectin and bioactive substances, and has great food and economic value. At present, studies have found that the content of polysaccharide in *S. spongiosa* is higher, because polysaccharides have antioxidant, anti-cancer, antibacterial, anti-aging, immune regulation and other activities, so it can be developed into health care products in the future[19, 20, 21]. The alcohol extract of the *S. spongiosa* has antibacterial and anti-cancer effects, indicating that it contains certain active substances, which provides a certain basis for future development into medicines. As there are few studies on *S. spongiosa*, some specific mechanism is not clear, and many effective components have not been found. The products circulating in the market are limited to fresh and dry products, and there are no deep-processed products for *S. spongiosa*, so the development of its deep-processed products remains to be discovered. The application of *S. spongiosa* to scientific research, medicine, health products and other aspects can bring great benefits to human beings. Therefore, the development prospect of *S. spongiosa* is great from many aspects.
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