processing methods have resulted in obvious variations in product quality. Therefore, how to coordinate yield improvement with quality optimization under artificial cultivation conditions has become an important issue in both industrial development and scientific research on *D. officinale* (Yuan et al., 2020; Zhang et al., 2023).

D. officinale is a typical epiphytic plant. Under natural conditions, it often grows attached to tree trunks, rock crevices, and other special habitats, and its roots have high requirements for the aeration, water retention, drainage, nutrient retention, and microecological environment of the growth medium. Therefore, in artificial cultivation systems, cultivation substrates are not only physical supports for plant attachment and growth, but also important factors regulating rhizosphere moisture, air, nutrients, and microbial environments. The commonly used substrates for *D. officinale* cultivation include pine bark, fern roots, sphagnum moss, biochar, mushroom residues, vermiculite, perlite, coconut coir, peanut shells, and composite substrates. These materials can, to some extent, simulate natural epiphytic habitats and provide roots with aeration, drainage, moisture retention, and nutrient-buffering conditions (He et al., 2022). Because different substrates vary significantly in pore structure, water-holding capacity, pH, nutrient content, and microbial composition, they exert important effects on root development, plant height, stem diameter, biomass accumulation, photosynthesis, stress resistance, and other growth indicators of *D. officinale* (Zhang et al., 2024). Previous studies have shown that pine bark-based substrates can improve the survival rate, plant height, stem girth, and dry weight of *D. officinale*, and show good production potential in some cultivation environments. Mixed substrates composed of pine bark and fern fiber can also support high acclimatization survival rates of tissue-cultured plantlets and favorable ex vitro growth performance (Luan et al., 2021; Wang et al., 2025). Meanwhile, substrates interact with ecological factors such as temperature, humidity, light, and nutrient status, thereby influencing the accumulation of polysaccharides, alkaloids, flavonoids, and other secondary metabolites, and ultimately determining the medicinal quality and commercial value of *D. officinale* (Yuan et al., 2020).

This review examines the effects of different cultivation substrates on the growth and quality formation of *D. officinale*. In recent years, related research has gradually expanded from simple comparisons of cultivation effects among different substrates to multiple aspects, including substrate physicochemical properties, rhizosphere microbial communities, ecological factor interactions, and quality formation mechanisms. Existing studies have shown that substrate selection and cultivation mode jointly affect the growth performance, survival rate, stress resistance, and bioactive compound accumulation of *D. officinale*. However, current research still has certain limitations. Many studies focus on single substrate formulations, specific regions, or individual indicators such as polysaccharide content, lacking systematic integration of multi-component quality evaluation involving polysaccharides, alkaloids, flavonoids, and phenolic compounds. In addition, the relationships among substrate characteristics, ecological factors, metabolite profiles, and molecular regulatory mechanisms have not yet been fully clarified, and substrate evaluation standards and industrial application specifications still require further improvement. Based on a review of relevant domestic and international studies, this paper systematically summarizes the types and characteristics of commonly used cultivation substrates for *D. officinale*, focuses on analyzing the effects of different substrates and related cultivation modes on plant growth and development, bioactive compound accumulation, and quality formation, and further discusses the possible mechanisms by which substrates regulate growth and quality, current research problems, and future development directions. This review aims to provide theoretical references and practical guidance for the scientific selection of cultivation substrates, optimization of artificial cultivation systems, and standardized, high-quality, and sustainable development of the *D. officinale* industry.

2 Types of Common Cultivation Substrates for *Dendrobium officinale*

2.1 Natural organic substrates such as sphagnum moss and bark

Natural organic substrates are widely used in the artificial cultivation of *Dendrobium officinale*. They are mainly derived from plant residues or natural organic materials and generally have good water retention, aeration, and root-attachment capacity, allowing them to partly simulate the natural epiphytic habitat of *D. officinale*. Among them, sphagnum moss is commonly used during tissue-cultured plantlet transplantation, seedling hardening, and