enzyme activity more effectively than white light. In contrast, continuous or intermittent red light delays or even completely inhibits fruiting body differentiation and is unfavorable for production (Liu et al., 2024). Earlier studies also found that light alone can induce primordium formation on agar medium, while the combined effects of light and ventilation can induce atypical fruiting structures with basidia and basidiospores, indicating a significant interaction between light and aeration. Therefore, facility-based *G. lucidum* production should rationally design light spectrum, light intensity, photoperiod, and ventilation regimes according to different growth stages and product goals.

3.3 Clean cultivation environment and pest and disease control in *Ganoderma lucidum* cultivation

Facility-based *G. lucidum* cultivation has a relatively long production cycle, and the substrates are rich in organic nutrients. In addition, high-temperature and high-humidity conditions can easily promote the proliferation of antagonistic fungi and pests. Therefore, clean-environment management is an important foundation for ensuring high-yield and high-quality production. Before production begins, cultivation rooms, inoculation rooms, cultivation racks, spraying systems, and production tools should be thoroughly cleaned and disinfected to reduce pathogen residues. Workers entering the production area should also undergo sanitation procedures to prevent external contamination sources from entering the cultivation environment. Studies have shown that in intensive *G. lucidum* facilities, colonies of *Trichoderma* and *Mucor* on the soil surface can increase significantly during cultivation, by up to 9~15 times; these fungi show strong antagonistic effects against *G. lucidum* in vitro and are closely associated with cultivation obstacles and failure of fruiting body development (Tong et al., 2020; Wang et al., 2022).

Contamination by competing microorganisms is one of the most common and serious problems in *G. lucidum* production. Contaminants such as *Trichoderma*, *Penicillium*, *Mucor*, and *Neurospora* compete with *G. lucidum* mycelia for nutrients and space and may inhibit *G. lucidum* growth through metabolic products, causing bag failure or even contamination of entire batches in severe cases. Continuous cultivation in the same soil can also lead to increases in organic matter and nitrogen levels, promoting the proliferation of competitive fungi and pathogens such as *Xylogone ganodermophthora*. This pathogen can reduce *G. lucidum* growth by more than 50%, leading to weak growth, aggravated disease, and yield decline (Tong et al., 2020; Huang et al., 2024). Therefore, thorough sterilization, clean substrate preparation, timely removal of contaminated bags, soil or substrate rotation, and avoidance of excessive nutrient accumulation are basic measures for disease control in facility-based *G. lucidum* production.

Pest and disease control should follow the principle of "prevention first and integrated control," combining physical control, biological control, environmental regulation, and necessary chemical intervention. Studies have shown that waterlogging treatment of cultivation soil can significantly reduce the numbers of *Trichoderma* and *Mucor* colonies, restore normal fruiting, and recover spore yield in soils where unsanitized conditions completely failed to produce spores, indicating the feasibility of physical sanitation treatment in large-scale application (Tong et al., 2020). For continuous cropping obstacles caused by *X. ganodermophthora*, low-concentration imazalil can effectively suppress the pathogen and promote *G. lucidum* growth when physical measures such as temperature and light are ineffective (Huang et al., 2024). At the same time, *Trichoderma*, as a typical biocontrol fungus, can exert antagonistic effects through competition, mycoparasitism, and antibiotic production. This indicates both its risk as a contaminant in *G. lucidum* cultivation and its potential value in ecological control of other plant diseases. Therefore, facility-based *G. lucidum* production should establish an integrated control system combining contaminant flora monitoring, preventive sanitation management, timely disinfection, and scientifically selected control agents to improve cultivation stability and product safety.

4 Key Technical Procedures for Standardized *Ganoderma lucidum* Production

4.1 *Ganoderma lucidum* strain selection and substrate standardization

Standardized production of *Ganoderma lucidum* first depends on the selection of superior strains and the optimization of substrate formulations. Strain quality directly determines mycelial growth rate, fruiting stability, fruiting body yield, and the accumulation of active components such as polysaccharides and triterpenoids.