

During fruiting body development, temperature, humidity, ventilation, and light should be managed synergistically. Low air humidity can easily cause cracking at the margin of *G. lucidum* fruiting bodies, thin pilei, and growth stagnation, whereas excessive humidity increases the risk of disease and contamination. Insufficient ventilation can cause CO₂ accumulation, leading to excessive stipe elongation and poor pileus development. Appropriate scattered light is conducive to pileus color formation and morphological integrity. Facility-based cultivation usually maintains a stable fruiting environment through scheduled spraying, mechanical ventilation, shading and light regulation, and environmental monitoring systems. In wild-simulated cultivation models, a relatively natural but still controllable fruiting environment can be created by removing the bags, covering beds with soil, managing dim light under the forest canopy, and biologically disinfecting ridges and surrounding areas (Dong et al., 2019). Potted and ornamental *G. lucidum* production places greater emphasis on fine control of temperature, humidity, and light to form fruiting bodies with ornamental value (Atila, 2020).

Mature *G. lucidum* should be harvested in a timely manner to avoid over-maturation, decline in appearance quality, and loss of active components. Harvesting is usually carried out when the pileus has fully expanded, the white growth ring at the margin disappears, spores begin to release, or the fruiting body reaches the target maturity stage. After harvesting, impurities should be removed promptly, and slicing, drying, grading, and packaging should be conducted according to product use. Drying methods significantly affect *G. lucidum* quality, as different drying methods can alter moisture content, rehydration capacity, phenolics, flavonoids, triterpenoids, polysaccharides, and antioxidant capacity (Atila, 2020; Naseri et al., 2023). Studies have shown that microwave drying, vacuum drying, freeze drying, hot-air drying, and infrared drying each have their own advantages. Among them, vacuum drying performs well in retaining active substances, bioavailability, and sensory quality, while infrared drying can shorten drying time and reduce energy consumption (Naseri et al., 2023). At the same time, HPLC fingerprints of multiple ganoderic acids and related markers can be used for quality control of dried fruiting body and spore products (Yeung et al., 2021). Therefore, standardized processing should clearly define harvest maturity, slice specifications, drying method, drying temperature, final moisture content, and chemical marker ranges to improve product quality stability and market competitiveness.

5 Quality Control System in Facility-Based *Ganoderma lucidum* Production

5.1 Whole-process record management of *Ganoderma lucidum* production

In facility-based production of *Ganoderma lucidum*, establishing a whole-process record management system covering pre-production, mid-production, and post-production stages is an important foundation for standardized production, quality control, and product traceability. Because the production cycle of *G. lucidum* is relatively long and involves multiple links, including germplasm resource management, strain cultivation, substrate preparation, sterilization and inoculation, mycelial incubation, fruiting management, harvesting and processing, packaging and storage, and product circulation, any deviation in any link may affect the final product quality. Wu et al. (2024) proposed that the *G. lucidum* industrial chain can be divided into pre-production links, including germplasm resource management and production area planning; mid-production links, including cultivation, harvesting, processing, and in-process quality control; and post-production links, including packaging, storage, circulation, quality evaluation, and traceability (Figure 2). Therefore, in facility-based production, information such as strain identity, raw material batches, substrate formulation, sterilization parameters, inoculation time, environmental control data, harvest stage, and processing conditions should be systematically recorded to ensure that each batch of products is traceable in source, controllable in process, and accountable in responsibility.

Environmental data recording is one of the core components of whole-process management. Environmental parameters such as temperature, humidity, light intensity, CO₂ concentration, ventilation status, and cleanliness directly affect mycelial growth, fruiting body formation, and active component accumulation in *G. lucidum*. Under facility-based cultivation conditions, intelligent sensors and automatic monitoring systems can be used to collect key environmental parameters in real time and establish dynamic production records. When abnormal growth, pest and disease occurrence, or quality fluctuations occur during production, environmental records and production operation records can be used for cause tracing, enabling timely adjustment of management measures.