For botanical insecticides on chrysanthemum, the 2024 evaluation under plastic house conditions reports that *Chrysanthemum cinerariaefolium* extract at 3.0–3.5 g/L achieved average efficacies of 76% and 72% against *Aphis gossypii*, and was the most consistent among tested botanicals. While *A. gossypii* is not the same as *Macrosiphoniella sanborni*, this study is still relevant for Hangbaiju because it provides a realistic magnitude of botanical suppression in chrysanthemum and supports the idea that botanicals can be more than marginal add-ons (Hutapea et al., 2024).

For microbial disease suppression, the Bacillus meta-analysis across 2000–2021 literature provides a broad benchmark: Bacillus-based biocontrol reduced disease by about 60% relative to controls, with higher efficacy in preventive contexts. This is not Hangbaiju-only, but it is a strong evidence synthesis that can guide expectations and program design (Serrão et al., 2024).

Hangbaiju-specific microbial evidence is available for Fusarium-related wilt management where Streptomyces metabolites were tested; reported results include stronger protective than therapeutic effects, reinforcing the practical principle that microbial control is best deployed before pathogen populations and vascular symptoms surge.

4.2 Effects on yield and product quality

Yield in Hangbaiju is inseparable from product quality because market grading is often driven by flower appearance, cleanliness, and consumer experience. A narrow harvest window means suboptimal timing can reduce both yield (lost harvest) and quality (flowers past peak or damaged). The Tongxiang survey described in the dataset paper emphasizes that Hangbaiju is harvested within a short period for best properties, linking agronomic timing directly to product value (Zang et al., 2023).

The aphid contamination case shows a quality dimension that is almost a “binary defect”: if aphid bodies appear in tea infusion, the product may be rejected regardless of yield. In this context, control measures that remove adults during bloom—without adding new residue concerns—can protect quality even if their effect on biomass yield is indirect. The attractant-baited yellow sticky traps described by Cao et al. are explicitly positioned as an “environmental sound measure” to combat bloom-stage aphids and reduce their presence in flowers (Cao et al., 2024). Microbial inoculants may also affect quality through plant physiology and nutrient use efficiency. The co-inoculation study in cut chrysanthemum reports improved growth and quality compared with single-strain inoculation and soil conditioner application, and connects these outcomes to changes in nutrient accumulation and gene expression in metabolic and signaling pathways. Although this was conducted in a cut-flower context rather than Hangbaiju tea production, it supports a plausible mechanism by which microbial management could improve Hangbaiju flower uniformity and stress resilience—traits that contribute to usable harvest (Wang et al., 2024).

4.3 Comparison with chemical control methods

A fair comparison with chemical control should acknowledge that chemical programs can deliver rapid suppression, especially when pest outbreaks are acute. Yet three comparative shortcomings often push Hangbaiju systems toward integrated biological control.

First, chemical sprays can be poorly matched to pest behavior. Thrips’ cryptic behavior and life cycle phases reduce spray contact efficacy, and resistance development can further erode performance. The chrysanthemum thrips biocontrol study uses this as a rationale for shifting toward biological control and IPM approaches.

Second, chemical control can undermine biological regulation by harming beneficial microbes and disrupting soil or rhizosphere functions. The PGPR study explicitly flags negative effects of chemical control on beneficial microbes, supporting the argument that the long-run “cost” of chemical programs includes ecological degradation and potentially rising disease susceptibility (Wang et al., 2024).

Third, chemical control during bloom is constrained by product identity and consumer perception. The bloom-stage aphid case provides a direct comparison: the study reports that traps combining yellow sticky boards