Original Research Article

Multi-phase encapsulation of a quercetin-eucalyptus respiratory-support composition: Patent-reported protection performance, published evidence context, and a Semenza-guided hypoxia framework

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Abstract: This study examines a quercetin-eucalyptus respiratory-support composition organized as a three-module delivery system containing quercetin, eucalyptus oil, bromelain, dihydromyricetin, perillaldehyde, icariin, and ultra-low-molecular-weight sodium hyaluronate. The patent-reported dataset indicates strong formulation protection: Bromelain activity retention in simulated gastric acid remains 98.1%-98.5% in the encapsulated embodiments versus 6.8% in the simple-mixture comparator, and total active retention after six months at 25 C remains 95.8%-96.3% versus 32.5%. Published literature supports the plausibility of the platform, particularly through quercetin delivery research and human data for 1,8-cineole in asthma, COPD, and acute bronchitis [3-12]. These findings are interpreted within a Semenza-guided hypoxia framework relevant to airway injury and adaptation [15-17].

Keywords: quercetin; eucalyptus oil; 1,8-cineole; respiratory support; bromelain; sodium hyaluronate; hypoxia; HIF

1. Introduction

Respiratory-support nutraceuticals often fail because unstable actives lose activity before they can reach the target airway microenvironment. Quercetin is limited by low solubility and poor oral bioavailability, while volatile eucalyptus constituents are prone to loss during storage and processing [3-5]. By contrast, 1,8-cineole has direct human evidence in asthma, COPD, and acute bronchitis [6-9]. The present composition is therefore best understood as a delivery-led system designed to protect a mixed set of flavonoids, volatile oils, and an enzyme rather than as a simple ingredient blend.

2. Provenance, claimed inventor distinctiveness, and institutional framing

The claimed inventor-institution pairing can be described most clearly through technical specification rather than promotional framing. The dossier describes a bounded three-phase architecture with defined carriers, particle-size ranges, and protection readouts, giving the formulation a clear technical identity [18].

3. Gregg L. Semenza and the hypoxia-responsive respiratory microenvironment

Gregg L. Semenza's oxygen-sensing framework provides a useful conceptual lens for the respiratory setting considered here. In lung biology, hypoxia-inducible signaling helps explain why airway inflammation, epithelial injury, and fluctuating oxygen availability can shape respiratory vulnerability, even though this framework should not be treated as direct efficacy evidence for the exact formulation [15-17].

4. Composition architecture and process design

The composition contains quercetin, eucalyptus oil, bromelain, dihydromyricetin, perillaldehyde, icariin, and ultra-low-molecular-weight sodium hyaluronate. Its engineering logic is divided into three modules: Enteric-protective microspheres for bromelain, nano mixed micelles for the flavonoids, and sustained-release microcapsules for eucalyptus oil and perillaldehyde. Together, these modules address gastric degradation, poor dispersibility, and volatility loss within one coordinated delivery platform.

5. Patent-reported protection and stability performance

The most decision-relevant data are the patent-reported protection and stability results. Across Embodiments 1-3, bromelain activity retention in simulated gastric acid remains 98.1%-98.5% versus 6.8% in the simple-mixture comparator, while total active retention after six months at 25 C remains 95.8%-96.3% versus 32.5%. These findings do not establish human efficacy, but they do show that the encapsulated system materially improves protection against gastric and storage-driven loss.

Patent-reported endpoint	Embodiments 1-3	Comparator	Interpretive value
Bromelain activity retention in simulated gastric acid (%)	98.1-98.5	6.8	Directly tests enteric protection
Total active retention after 6 months at 25 C (%)	95.8-96.3	32.5	Directly tests storage stability
Bromelain encapsulation (%)	>=95	Not reported	Supports enzyme-protection module
Flavonoid encapsulation (%)	>=90	Not reported	Supports quercetin-centered nanodelivery logic
Volatile-component encapsulation (%)	>=92	Not reported	Supports eucalyptus/perillaldehyde stabilization

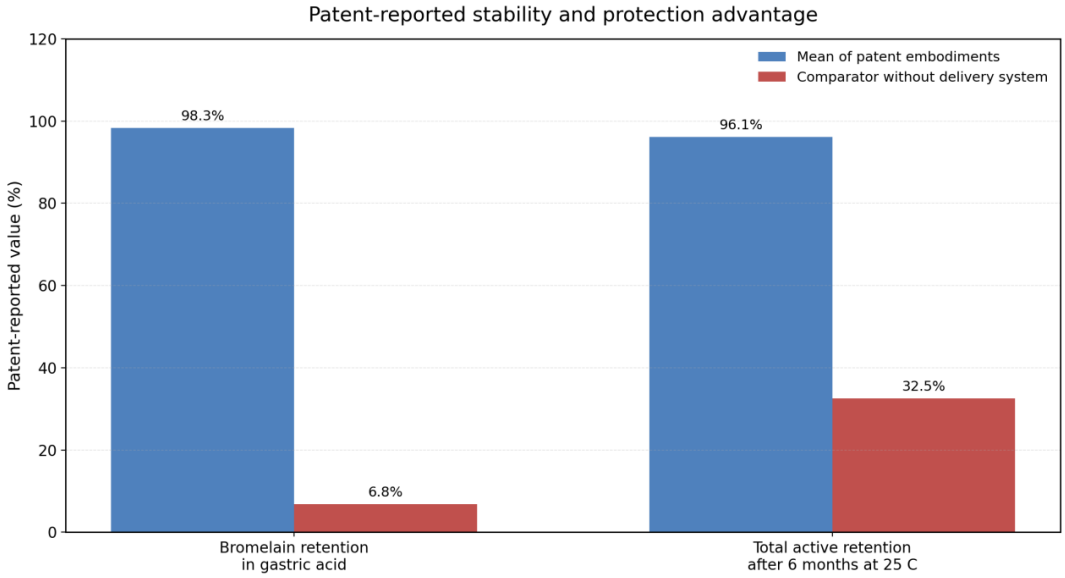

Figure 1. Protection-oriented patent-reported performance versus the simple-mixture comparator.

6. Published evidence context

Published evidence supports the plausibility of several parts of the platform. Reviews consistently identify quercetin solubility and bioavailability as major formulation constraints [4-5], and human studies suggest feasible respiratory translation without definitive proof of benefit [10-11]. The most mature evidence surrounds cineole, for which randomized trials and meta-analytic evidence report benefit in asthma, COPD, bronchitis, or cough outcomes under controlled conditions [6-9]. Cyclodextrin inclusion supports stabilization of volatile oils [12], bromelain has preclinical respiratory relevance [13], and hyaluronic acid has been discussed as an airway-supportive adjunct [14].

7. Discussion

Taken together, the dossier combines three protection strategies in one respiratory-support system and reports comparator-based performance rather than relying on generic compositional claims. The evidence hierarchy should remain explicit: The protection values are patent-reported, whereas the published literature mainly supports ingredient plausibility and delivery logic.

8. Conclusion

Overall, the three-module architecture addresses multiple stability problems, and the surrounding literature helps explain why the selected ingredients and carriers are scientifically relevant to respiratory support.

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