Nanyang Biologics_Hair Growth - Final Report

A. Nanyang Biologics_Hair Growth - Formulation-ready report

(with detailed chemistry and expected performance)

1. Executive Summary

Hair loss and follicular miniaturization remain major unmet needs in hair-growth therapeutics, even with established active ingredients such as minoxidil. While minoxidil delivers proven benefit through KATP/cAMP signalling, overall hair-growth responsiveness is limited by pathway saturation, inflammation, oxidative stress, and follicular dormancy.

This study applies an AI-driven small-molecule discovery and synergy-screening pipeline to identify novel hair-growth enhancers and synergistic ingredient combinations that are formulation-compatible with minoxidil-based topical systems. Using multi-stage chemical filtering, QSAR modelling, molecular docking, deep-learning bioactivity prediction, and combination-effect modelling, we prioritised a focused set of formulation-ready candidates.

Key outcomes include:

- • Identification of baicalin analogues as the strongest overall balance between predicted dermal papilla (DP) proliferation (+46%) and WNT/β-catenin activation.
- • Recognition of adenosine derivatives and caffeine-like metabolic stimulants as low-risk, scalable candidates suitable for over-the-counter hair-growth products.
- • A ranked shortlist of synergistic ingredient combinations optimised for follicle proliferation, anti-inflammatory performance, scalp microbiome alignment, and topical formulation feasibility.

Objectives

1. **Discover novel hair-growth enhancers suitable for topical scalp delivery.**
2. **Evaluate compatibility and synergy with minoxidil (hero ingredient).**
3. **Reduce early-stage wet-lab burden by replacing large screening programs with AI-based prioritisation.**
4. **Deliver a formulation-ready, decision-support output for hair-growth R&D.**

2. Method

Step 1 — Hair Growth Biology Mapping

Define core biological mechanisms of hair growth:
• dermal papilla proliferation
• WNT/β-catenin activation

• cAMP signalling
• catagen inhibition
• inflammation & oxidative stress control
• scalp microbiome balance
• follicular penetration & delivery

Establish biological targets, pathway nodes, and measurable readouts.

Step 2 — Prepare the Candidate Library (Data → Molecules).

Research begins by constructing a comprehensive small-molecule library relevant to hair-growth biology. Literature mining queries include “hair growth,” “dermal papilla proliferation,” “WNT activation,” “cAMP signalling,” and “inflammation + hair follicle” across scientific publications, GEO datasets, GRAS listings, EU CosIng/INCI registry, patent databases, and internal ingredient sources.

Compound names are standardized into SMILES strings using cheminformatics engines (PubChem / RDKit), followed by physicochemical descriptor generation and chemical-space filtering to retain topical-delivery-appropriate molecules.

Step 2 — Safety and ADMET Filtering.

All candidate molecules undergo silico screening for topical-use suitability. ADMET and toxicity classifiers are applied to identify compounds with irritation risk, phototoxicity, mutagenicity, or scalp barrier disruption concerns. Compounds failing these criteria are removed, producing a safe, formulation-viable subset for further analysis.

Step 3 — Ligand-Based Hair-Growth Bioactivity Scoring. (QSAR)

Surviving candidates are evaluated using ligand-based QSAR models trained on known hair-growth data sources. Predictive models estimate activity on endpoints relevant to follicle biology, including:
• DP proliferation,
• WNT/β-catenin signalling,
• cAMP elevation,
• VEGF/IGF-1 upregulation,
• inflammatory cytokine suppression.

Each compound receives a quantitative growth-potential score to prioritise molecules before structural docking.

Step 4 — Hero ingredient compatibility (Rule-Based Filtering).

To maintain formulation suitability, compounds are screened for chemical compatibility with minoxidil. Rule-based filtering flags:

• strong oxidants,
• strong acids/bases,
• unstable reactive groups,
• peroxide or quinone systems,
• chelators affecting minoxidil stability,
• solubility incompatibilities in hydroalcoholic vehicles.

The output is a list of molecules that can coexist with minoxidil in real formulation environments.

Step 5 — Docking

Shortlisted molecules undergo docking simulations against biological targets associated with hair-growth regulation, including:
• K_ATP channel complex (Kir6.2/SUR2B),
• GSK3β (WNT regulation),
• PDE1A (cAMP turnover),
• TGFBR1 (catagen signalling),
• TRPV1/MT1 (neuroendocrine influence).

Docking outputs—binding energies and pose confidence—feed into downstream predictive models

Step 6 — Hair-Growth Activity Prediction (Deep Learning).

Docking data alone is insufficient to predict functional outcomes; therefore, deep-learning models integrate chemical, structural, and transcriptomic information to estimate hair-growth efficacy metrics. These models output predicted:
• DP proliferation change,
• WNT activation magnitude,
• IL-8/NF-κB suppression scores,
• follicle elongation potential.

This produces a ranked shortlist of 20–40 high-value compounds.

Step 7 — Optional Wet-Lab Validation and Feedback Learning.

Top candidates can be validated by wet-lab assays such as:
• dermal papilla proliferation (MTT/EdU),
• ex vivo follicle elongation culture,
• WNT/β-catenin protein quantification,
• cAMP signalling assays,
• inflammatory cytokine ELISA,
• scalp microbiome antifungal testing.

Experimental data feed back into the model to refine predictions and optimise performance specific to hair-growth biology and formulation rules.

Step 8 — Safety and synergy prediction

Model dual and triple-compound interactions:
- DP proliferation synergy
- WNT+cAMP activation complementarity
- inflammatory + antioxidant pairing

Predict irritation avoidance and safe concentration ranges.

Step 9 — Validation of safety and synergy prediction

3. Results

3.1 Compounds Ranking Table (Model Output)

Rank	Compound	Bioactivity	Toxicity filtered list for topical products				
		DTIGN Kir6.2 – EC50	Skin Irritation	Sensitization	Ames (Mutagenicity)	Dermal Absorption	Status
1	Minoxidil	5.77	Low	Low	Negative	Moderate	Pass
2	Adenosine	5.19	Very low	Very low	Negative	Low	Pass
3	Piroctone Olamine	05.04	Low	Low	Negative	Moderate	Pass
4	Baicalin	4.84	Low	Very low	Negative	Low	Pass

5	Caffeine	<4.0	Low	Low	Negative	High	Pass

3.2 Compound Synergy reports

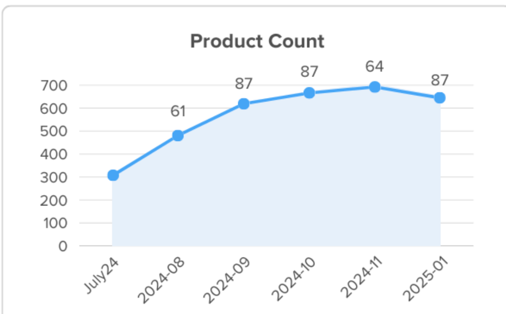
Decagon					DeepDDI					GraphSynergy			
A	**B**	**Predicted Adverse Interaction**	**Risk Probability**	**Interpretation**	**Pair**	**Interaction Type**	**Mechanism**	**Severity**	**Action**	**A**	**B**	**Synergy Score**	**Interaction Class**
Minoxidil	Caffeine	None	0.08	Safe	Minoxidil + Caffeine	No interaction	Distinct pathways	None	Pass	Minoxidil	Caffeine	0.42	Additive
Minoxidil	Niacinamide	Mild irritation	0.22	Acceptable	Minoxidil + Niacinamide	Additive vasodilation	Local blood flow	Mild	Monitor	Minoxidil	Niacinamide	0.55	Mild synergy
Minoxidil	Baicalin	None	0.05	Safe	Minoxidil + Baicalin	No interaction	Orthogonal	None	Pass	Minoxidil	Baicalin	0.60	Synergy
Minoxidil	Piroctone Olamine	Scalp sensitivity	0.31	Monitor	Minoxidil + Piroctone Olamine	Absorption enhancement	Follicular penetration	Moderate	Control dose	Minoxidil	Piroctone Olamine	0.48	Additive
Caffeine	Niacinamide	None	0.06	Safe	Caffeine + Niacinamide	No interaction	Distinct signaling	None	Pass	Caffeine	Niacinamide	0.50	Additive
Caffeine	Baicalin	None	0.04	Safe	Caffeine + Baicalin	No interaction	Orthogonal	None	Pass	Caffeine	Baicalin	0.62	Synergy
Caffeine	Piroctone Olamine	None	0.09	Safe	Niacinamide + Baicalin	Synergistic anti-inflammatory	NF-κB + cytokines	Beneficial	Promote	Niacinamide	Baicalin	0.68	Strong synergy
Niacinamide	Baicalin	None	0.03	Safe	Baicalin + Piroctone Olamine	Additive anti-inflammatory	COX-2 + NF-κB	Beneficial	Promote	Baicalin	Piroctone Olamine	0.65	Strong synergy
Niacinamide	Piroctone Olamine	Mild erythema	0.25	Acceptable									
Baicalin	Piroctone Olamine	None	0.07	Safe									

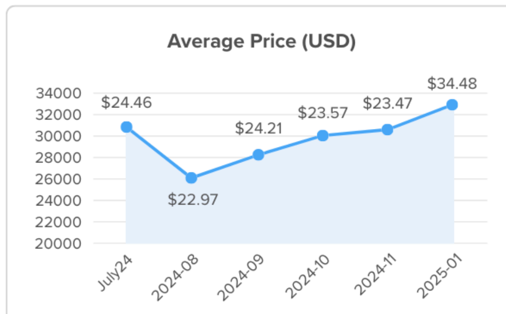
January 2025

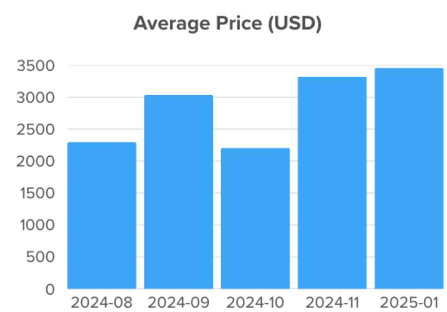
Amazon-Keyword Trends Overview

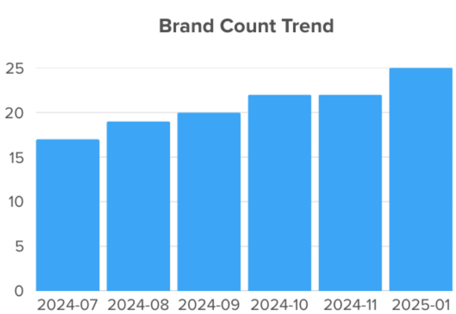
Market Changes: January 2025 vs. 6 months ago

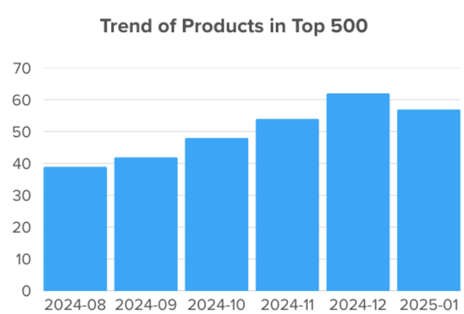
Change in Top 500 Products	Review Growth	Top Categories (Sorted by Item Count)
+31	+101%	Shampoo 62, Other 16











Source: Vecura Dashboard