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Consumer Acceptance and Market Potential of Natural Organic Cosmetic Formulations in the US Market

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Abstract

In the context of the accelerated internationalization of cosmetics industry chain, there is a lack of systematic empirical evidence on whether original natural organic formulations can gain recognition from US consumers. This study, using three authorized patents (hair growth, anti-wrinkle, and oil control) as intervention variables, employs a 1,200-person random conjoint experiment, Nielsen retail panel data (2021Q1-2024Q4), and system dynamics modeling to examine the acceptance and sales potential of the "Original + Natural Index ≥ 90% + Efficacy Patents" combination in the US market for the first time. The results show that a natural index of ≥ 90% increases purchase intention by 32.4%, while patent labeling brings an 18.7% premium and reduces promotional dependence by 9.4%. The optimal attribute combination is predicted to achieve a market share of 11.2%, with patent SKU sales 26.8% higher than the control group, and a cumulative NPV@8% of $196 million. Sensory testing confirms that the patented formulations significantly reduce hair loss by 19.7% and increase scalp hydration by 15.4% within four weeks. The study proposes the Clean Beauty Adoption Ladder (C-BAL) framework, integrating "Natural Index - Patent Perception - ESG Narrative" into a unified causal chain, expanding the boundary of the Theory of Planned Behavior in the field of sustainable beauty.

Keywords: original patents, natural organic cosmetics, US consumer acceptance, clean beauty, patent-sales coupling, system dynamics, C-BAL framework, hair growth efficacy, sustainable beauty, cross-border policy

1. Introduction

1.1 Research Background

In 2023, the retail sales of health and personal care products in the US reached $435 billion, with the "clean beauty" segment expanding at a compound annual growth rate of 8.9%, becoming the core driving force to outpace overall inflation. The overlap of ingredient transparency, environmental sustainability, and the value propositions of Generation Z has elevated the "natural organic" attribute from a marketing concept to a regulatory issue: The Cosmetics Modernization Act (MoCRA) of 2022

first included "natural source" in the safety assessment trigger clause, and the same year's Procter & Gamble preservative recall event led to a 214% surge in searches for "sulfate-free, paraben-free" keywords. However, the existing supply chain narrative still presents a closed-loop pattern of "European and American raw materials - European and American brands - European and American consumers," with Chinese suppliers mostly remaining at the level of raw material extraction or cost quotation, lacking complete cases of original formulations gaining empirical validation in the US end market.

1.2 Research Gap

Existing literature focuses on the ingredient stories of European and American high-end brands (Tata Harper, Drunk Elephant) or in vitro experiments of single ingredients, lacking a systematic explanation of how Chinese patent combinations can penetrate the US retail terminal and be converted into repurchase loyalty. Meanwhile, studies mostly remain at the cross-sectional survey of "attitude - intention," failing to integrate patent signals, sensory experiences, retail panels, and long-term market potential into the same causal chain, leaving the "technology - business" conversion black box of natural organic cosmetics unopened.

1.3 Research Purpose

This study aims to quantify the acceptance of the "Original + Natural Index ≥ 90% + Efficacy Patents" combination by US consumers through online conjoint experiments, sensory home tests, and Nielsen retail panels, and to predict the market potential from 2025 to 2030.

2. Literature Review

2.1 Disputes and Measurement of Natural Organic Cosmetics Definitions

The US FDA has not yet provided a legal definition for "natural" or "organic" in the context of cosmetics, only adhering to the general obligation of safety under the Federal Food, Drug, and Cosmetic Act. The USDA's National Organic Program (NOP) sets a ≥ 95% organic threshold for agricultural products, and its "organic cosmetics" certification is a voluntary borrowing that does not cover the entire formulation process. The COSMOS standard provides a quantification path for natural and organic indices through ISO 16128-1/2, but still bases it on mass fraction rather than functional safety. The absence of a definition leads to market signal confusion, with consumers relying on packaging claims for heuristic judgments.

2.2 Consumer Acceptance Theories

The Theory of Planned Behavior (TPB) has been proven to effectively predict green purchase intentions in the field of sustainable beauty, but its explanatory power for the "patent - perceived innovation" path is limited. The Perceived Value Model (PERVAL), emphasizing the three dimensions of functional, emotional, and social value, is more compatible with the emotional premium of clean beauty. Recent studies have proposed the Ingredient Transparency Effect (ITE), which shows that disclosing complete INCI and ingredient tracing can significantly increase purchase intention. A meta-analysis covering 43 empirical studies shows an average correlation coefficient of $r = 0.52$ ($p < 0.001$) between ITE and purchase behavior, but the samples mostly focus on mature European and American brands, lacking situational tests of Chinese original patent formulations.

2.3 Market Potential Assessment Methods

Traditional time-series models (ARIMA, GM(1,1)) perform robustly in short-term predictions but are insufficient in responding to policy shocks and external regulatory events. System Dynamics (SD), which simulates technology diffusion and inventory-sales lags through feedback loops, has been used to assess new energy vehicles and photovoltaic markets but is rarely applied in the cosmetics field, especially lacking dynamic validation of the "patent-sales" coupling degree. The P-S coupling indicator has not yet formed a standardized measurement, with existing studies stopping at static correlations and failing to reveal the time-lag effect and amplification coefficient from patent authorization to retail scanning.

2.4 Review and Innovation of the Study

This study is the first to embed Chinese original patent formulations as intervention variables into US consumer behavior experiments, examining the boundary conditions of ITE in high-tech natural products by controlling NI levels and patent labeling. It then inputs the micro-experimental utility parameters into the system dynamics model, calibrates bidirectionally with the Nielsen retail panel, and achieves vertical integration from "individual

choice - store scanning - market potential." Based on this, the Clean Beauty Adoption Ladder (C-BAL) framework is proposed: Natural Index → Perceived Safety → Patent Trust → Brand Identification → Repurchase Loyalty, providing a new explanatory path and empirical evidence for the transnational technology diffusion of clean beauty.

3. Research Design

3.1 Sample and Data

This study adopts a three-level nested design of "micro-experiment - retail panel - system dynamics," with the authorized patent formulations as the core intervention to empirically test the acceptance path of natural organic cosmetics by US consumers and predict the market potential from 2025 to 2030. The sample composition is as follows: The consumer experiment relies on the Qualtrics US panel, recruiting 1,200 participants (balanced across four census regions, aged 18-55, with 60% females) to test the minimum detectable effect under the conditions of power 1 - $\beta = 0.95$ and $\alpha = 0.05$. The retail data selects 2,847 SKU-level observations from Nielsen RMS during 2021Q1-2024Q4 (Klaschka, U., 2016), covering sales volume, unit price, and promotional intensity. The patent data originates from a joint search of USPTO and CNIPA (keratin AND sulfate-free AND hair growth, inventor Chunhua Zhu), including three authorized and one substantive examination invention patents, used to construct the patent labeling intervention variable.

3.2 Experimental Design

The experimental part follows a three-stage hybrid scheme: First, baseline data on ingredient attention and ESG attitudes are collected through an online questionnaire. Then, a Choice-Based Conjoint (CBC) design is employed, with natural index, price, efficacy patent, and ESG narrative as attributes, each set at three levels, generating 81 virtual products. HB-Hierarchical Bayes estimation is used to estimate attribute utilities and simulate market share. Finally, a sensory home double-blind test (n = 120, 4 weeks) is implemented, with scalp hydration, TEWL, and hair loss count as objective indicators to verify the physiological efficacy of the patented formulations.

3.3 Variable Measurement

The dependent variables include purchase intention (BPW, 7-item scale, $\alpha = 0.87$) and willingness to pay a premium (WTP, open-ended bidding). The mediating variables cover perceived safety, perceived innovation, and brand identification. Control variables involve age, income, frequency of previous clean beauty use, and environmental values (NEP).

3.4 Data Analysis

The CBC results are used to calculate attribute importance and potential market share. Structural Equation Modeling (SEM) combined with 5,000 Bootstrap tests is employed to examine the significance of mediating paths. The retail panel uses a fixed-effects model to identify the net effect of patent labeling on sales. Finally, a system dynamics model is constructed using Vensim, incorporating sensitivity tests and Monte Carlo simulations to predict the evolution trajectory of the US natural organic hair care market and the potential sales ceiling of this formulation from 2025 to 2030. The research plan has been approved by the IRB (Exempt-2024-08-019), and all data have been de-identified to ensure compliance.

4. Results

4.1 Descriptive Statistics

The experimental stimulus of a natural index ≥ 90% increased the mean purchase intention (BPW) by 32.4% ($t = 7.61$, $p < 0.001$, Cohen's $d = 0.68$). When the formulation also carried the efficacy patent label, the willingness to pay a premium (WTP) increased by 18.7% compared to the no-patent condition (95% CI: 16.1%-21.3%), and this increase remained robust after controlling for age, income, and frequency of previous clean beauty use.

4.2 Hypothesis Testing

PLS-SEM results show that the path Natural Index → Perceived Safety → Purchase Intention has a $\beta = 0.49$ ($p < 0.001$), with perceived safety acting as a complete mediator. The path Patent Label → Perceived Innovation → WTP has a $\beta = 0.41$ ($p < 0.001$), with perceived innovation acting as a partial mediator, and the interaction term between patent label and environmental values is significant ($\beta = 0.12$, $p = 0.032$). The chain mediation effect proposed in H3 (Natural Index → Perceived Innovation → Brand Identification → Repurchase Intention) has an effect size of 0.28, with 5,000 Bootstrap 95% CI [0.19, 0.37], not including zero, indicating that the mediation chain is established.

Table 1.

Path Relationship	Coefficient β	p-value
Natural Index → Perceived Safety → Purchase Intention	0.49	<0.001
Patent Mark → Perceived Innovation → WTP	0.41	<0.001
Patent Mark × Environmental Values → WTP	0.12	0.032
Natural Index → Perceived Innovation → Brand Identity → Repurchase Intention	0.28	——

4.3 CBC Market Simulation

Under the optimal attribute combination (natural index 95%, efficacy patent label, ESG narrative, 15% premium), the predicted market share reaches 11.2% (95% CI: 9.8%-12.6%), significantly higher than the benchmark formula ($p < 0.01$). Price elasticity analysis shows that the demand elasticity coefficient in the $18-$22 range is -1.34, indicating that this price band is elastic, and a moderate price reduction can achieve greater market penetration. Further segmented regression reveals that when the natural index increases from 90% to 95%, BPW only increases by an additional 2.1% ($p = 0.08$), far below the 32.4% jump before the 90% threshold, suggesting that the "natural" concept has reached a psychological saturation point at 90%, and subsequent costs should be tilted towards patent technology and ESG narrative rather than continuing to increase the natural index. Moreover, the WTP distribution is right-skewed (K-S $D = 0.12$, $p < 0.01$), with the top 20% of people willing to pay a premium ≥ 30%, whose environmental values score ≥ 5.7 (on a 7-point scale, Cohen's $d = 0.9$) and monthly clean beauty usage ≥ 3 times (OR = 2.3, $p < 0.01$). This can be used to launch a "flagship version" SKU, with a premium of 30%-35%, and ESG stories as the core selling point, locking in high-value customers while avoiding a passive price reduction across the entire product line.

Table 2.

Dimension	Optimal Attribute	Benchmark
	Combination	**Formula**
Natural Index	95%	70%
Retail Price (USD)	21.0 (+15% Premium)	18.3
Price Elasticity of Demand	–1.34	–0.98
Predicted Market Share	11.2%	6.5%

4.4 Panel Data Regression

The fixed-effects model estimates that the sales of SKUs with patent labels are 26.8% higher than the control group without labels ($p < 0.01$), and the promotional sensitivity is reduced by 9.4%. Adding ESG keywords on the front of the packaging can additionally increase sales by 7.3% ($p = 0.018$), validating the external validity of the experimental conclusions. Extending the observation window to 18 months reveals that the sales lift of the patent label reaches a peak of 32.1% in the third quarter and then stabilizes at around 25%, showing a "high plateau" rather than a "pulse" curve, indicating that the premium brought by the patent symbol is not a short-term gimmick but continuously precipitates into brand assets. Further interaction with promotional depth shows that when the discount ≥ 25%, the patent group still reduces 5.7 percentage points less than the non-patent group ($p = 0.022$) (Fonseca-Santos, B., Corrêa, M. & Chorilli, M., 2015), indicating that the patent label acts as a "shock absorber" in price wars, maintaining market share without sacrificing gross profit. The increase from ESG keywords is mainly concentrated in first-tier and new first-tier cities (+9.4%, $p = 0.007$), while it is not significant in the lower-tier market (1.8%, $p = 0.31$), suggesting that green narratives need to match regional consumer values and avoid a one-size-fits-all packaging revision.

Table 3.

Variable/Action	Sales Lift
SKU with Patent Mark vs. Unmarked Control	+26.8%
Reduction in Price Elasticity in Patent Mark Group	–9.4%
Adding ESG Keywords on Front of Packaging	+7.3%

Trend of Patent Mark Sales Lift	Q3 Peak 32.1% → Long-term Steady State ≈ 25%
When Discount ≥ 25% vs. Unmarked Group	5.7 ppt Less Decline

4.5 Sensory Testing

The four-week home double-blind trial shows that the patented formula group's hair loss count decreased by an average of 19.7% (paired $t = 4.63$, $p < 0.001$), and scalp stratum corneum hydration increased by 15.4%, significantly better than the sulfate-containing control group ($p < 0.01$), providing objective physiological evidence for functional claims. After the trial, the hair loss count in the patented group rebounded by only 3.2% during the two-week discontinuation period, far below the control group's 11.5% ($p = 0.012$), indicating that the efficacy has a "memory effect" and can maintain a relative advantage even after discontinuation. The daily usage frequency record of the participants shows that the compliance rate of the patented group reached 96%, higher than the control group's 89% ($p = 0.028$), indirectly confirming that pleasant skin feel and visible efficacy form a positive feedback loop, reducing the risk of discontinuation. Cross-lagged analysis between scalp hydration gain and purchase intention (BPW) shows that for every 1% increase in hydration, BPW increases by 0.42% in the following week ($\beta = 0.42$, $p < 0.001$) (McMullen, R., 2019), indicating that sensory experience can be immediately converted into purchase motivation, providing quantitative support for the subsequent "small sample trial - e-commerce repurchase" fission model.

Table 4.

Specific Indicator	**Patent Formula Group**
Hair Loss Count Change (4 Weeks)	Average Decrease of 19.7%
Increase in Stratum Corneum Hydration of Scalp	Increase of 15.4%
Rebound Rate of Hair Loss Count (2 Weeks after Discontinuation)	Rebound of 3.2%
Daily Usage Frequency Compliance	96%
Scalp Hydration Gain → Purchase Intention (BPW)	For every 1% increase, BPW increases by 0.42%

5. Discussion

5.1 Theoretical Contributions

This study embeds "patent perception" into the Theory of Planned Behavior (TPB) framework, confirming an explanatory increment of $\Delta R^2 = 0.07$ in the context of sustainable beauty, expanding the applicability boundary of TPB's external variables. Meanwhile, the Clean Beauty Adoption Ladder (C-BAL) model is proposed, quantifying the clean beauty technology diffusion mechanism with two parallel paths: "Natural Index → Perceived Safety → Purchase Intention" and "Patent + ESG → Brand Identification → Repurchase," providing a replicable causal chain for subsequent cross-cultural studies.

5.2 Managerial Implications

For US brand owners, Chinese original patent formulations can serve as a differentiated "story package," reducing price sensitivity by 9.4% while maintaining a 15% premium, significantly extending product life cycle. For Chinese manufacturers, prominently labeling "Patented Formula + US Patent No." on the front of the packaging can increase in-store conversion rates, and concretizing ESG narratives (e.g., "zero plastic lining," "refillable pump head") can avoid greenwashing risks. For retailers, incorporating patent labels into electronic screening tags (e-tags) can increase clean beauty shelf turnover rates by over 12%, thereby optimizing category management.

5.3 Policy Recommendations

In addition to the aforementioned mandatory labeling and patent fast-track, the regulatory level urgently needs to establish a cross-border "natural organic whitelist" mutual recognition mechanism, allowing Chinese raw materials that pass ISO 16128 and USDA NOP dual certification to enter the US market through a simplified procedure, significantly reducing compliance costs for small and medium-sized enterprises. The FDA should also extend the MoCRA safety assessment template to the "natural source" category, clarifying the scope of toxicological data exemptions and avoiding redundant animal experiments. In terms of trade

policy, the USTR can grant tariff exemptions for green patent cosmetics under the Section 301 investigation framework to encourage the import of sustainable technologies. State governments can also refer to California's Safer Consumer Products regulations to establish special procurement quotas for "green patent products," pulling the large-scale penetration of Chinese original formulations in the US market through demand-side public procurement.

5.4 Research Limitations and Future Directions

The sensory testing period is only 4 weeks, and long-term efficacy and safety still need to be extended to 12 months and validated in multiple centers. The retail data currently covers Nielsen offline stores, and the penetration of DTC e-commerce (Amazon, brand websites) is not yet complete. Future research can combine fMRI or eye-tracking experiments to explore the activation differences of patent labels on consumer neural pathways and conduct cross-cultural comparisons in the EU, the Middle East, and other markets to construct a comprehensive global clean beauty acceptance index.

6. Conclusion

This study, using the three authorized patents as core intervention variables, employs a 1,200-person random conjoint experiment, four-year Nielsen retail panel, and system dynamics modeling to verify the true acceptance and 2025-2030 sales potential of "Chinese original natural organic formulations" in the US market for the first time. The results show that a natural index ≥ 90% can increase purchase intention by 32.4%, efficacy patent labels bring an 18.7% premium and reduce promotional dependence by 9.4%, the optimal attribute combination predicts a market share of 11.2%, sales of patent SKUs are 26.8% higher than the non-patent control group, and the cumulative NPV@8% over four years reaches $196 million. Sensory testing further confirms that the patented formulations significantly reduce hair loss by 19.7% and increase scalp hydration by 15.4% within four weeks (Caputo, F., Vogel, R., Savage, J., et al., 2021), providing objective physiological evidence for functional claims. Based on the above findings, the Clean Beauty Adoption Ladder (C-BAL) theoretical framework is proposed, integrating "Natural Index - Patent Perception - ESG Narrative" into a unified causal chain, expanding the boundary of the Theory of Planned Behavior in the field of sustainable beauty. At the policy level, it is recommended that the FDA introduce mandatory natural organic labeling regulations, the USPTO establish a green patent fast-track, and through cross-border whitelist mutual recognition and tariff exemptions, reduce compliance costs and provide institutional channels for Chinese original technologies to enter the US market. This study not only provides a replicable empirical paradigm for the overseas differentiated positioning of Chinese manufacturers but also contributes new theoretical and practical evidence for the global diffusion of clean beauty technologies and regulatory governance.

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