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Formulation, Development, and Evaluation of a Novel Long-Lasting Herbal Deodorant Roll-On Using Layered Fragrance Technology

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Abstract:

Body odor (bromhidrosis) represents an unpleasant cutaneous phenomenon arising from the microbially-mediated biotransformation of naturally odorless apocrine and eccrine sweat gland secretions. While modern consumer preferences increasingly lean toward botanical alternatives due to concerns regarding dermal irritation, chemical toxicity, and cumulative system effects of synthetic aluminum salts and paraben preservatives, formulating highly effective, long-lasting herbal deodorants remains an industrial challenge. This research paper describes the systematic design, development, optimization, and comprehensive evaluation of a premium natural roll-on herbal deodorant (100 g formulation) utilizing specialized botanical phyto-actives—primarily Aloe vera gel (20% w/w), Neem (Azadirachta indica) extract (10% w/w), and Rose water (15% w/w)—stabilized within an organic lipid matrix of Coconut oil (10% w/w) and Beeswax (8% w/w). To enhance sensory longevity and continuous performance, an advanced Layered Fragrance System was engineered, structuralizing top notes (Citrus oil and Mint extract) for an instantaneous baseline freshness, middle notes (Lavender oil and Neem accord) as the fundamental herbal identity, and base notes (Sandalwood oil and White musk accord) to facilitate structuralized aromatic fixation. Organoleptic assessments showed excellent physical homogeneity, a premium light-green to off-white aesthetic presentation, smooth non-greasy spreadability, and an ideal topical pH range of 5.5 to 6.2 matching the physiological acid mantle. In vitro antimicrobial challenge evaluations revealed pronounced zones of inhibition against standard dermal microflora, driven by the synergistic action of Azadirachta indica bio-actives. Accelerated stability profiles under varying thermal regimens (refrigerated, ambient, and 48°C) demonstrated structural integrity with zero phase separation, validating its clinical safety and scalable market readiness as a modern therapeutic eco-cosmetic solution.

Keywords: Herbal Cosmetics, Azadirachta indica, Bromhidrosis, Layered Fragrance Technology, Microencapsulation, Skin Compatibility, Formulation Engineering.

Introduction

A deodorant is a classic cosmetic and personal hygiene product purposefully formulated to prevent, suppress, or mask unpleasant body odors caused by the bacterial decomposition of perspiration on the epidermis. Sweat itself, secreted by specialized cutaneous glands, is inherently odorless; however, resident epithelial

microflora metabolize its organic fractions into volatile, pungent molecular compounds. This occurrence presents a major personal hygiene and social grooming concern across modern global populations, driving the demand for reliable personal care products.

Physiological Mechanisms of Sweat Glands and Pathogenesis of Odor

To successfully engineer an advanced deodorant system, the underlying physiological and anatomical architecture of human sweat glands must be thoroughly examined. The human integumentary matrix houses millions of highly specialized exocrine glands distributed across different dermal zones, categorized into two main configurations: eccrine and apocrine glands.

Eccrine Glands: These represent the most widely distributed, highly abundant coiled tubular exocrine structures located extensively across the body surface, particularly concentrated on the palmar surfaces, plantar regions, and the forehead. Their fundamental metabolic function centers on systemic thermoregulation. The primary fluid secreted is a clear, low-viscosity, completely odorless aqueous solution primarily composed of water (99%), sodium chloride, trace metabolic elements, and specific antimicrobial peptides. Its cooling mechanism relies entirely on the thermodynamics of evaporative heat dissipation.

Apocrine Glands: In contrast, apocrine glands exhibit localized distribution, concentrated within the axillary vaults, groin, perineal regions, and circum-areolar tissue rings. These structures remain dormant during early childhood, undergoing rapid physiological activation during puberty under hormonal control. Apocrine sweat is structurally distinct, characterized by a thick, milky, macromolecule-rich secretion high in proteins, lipids, carbohydrates, steroids, and volatile organic compounds. When released onto the epidermal boundary, it undergoes extensive enzymatic decomposition by ambient Gram-positive skin bacteria, establishing the clinical manifestation of bromhidrosis.

Consequently, targeted cosmetic interventions focus their chemical mechanics directly onto the specific remediation of axillary apocrine fluid transformations. Traditional synthetic antiperspirants typically introduce inorganic aluminum chlorohydrate or aluminum zirconium complexes. These salts interact with the sweat components, creating a physical polymeric plug within the luminal duct to mechanically obstruct secretion. However, recent toxicological and dermatological investigations have associated long-term exposure to synthetic aluminum salts and paraben-class preservatives with contact dermatitis, localized glandular inflammation, epidermal micro-abrasions, and broader systemic concerns. This pattern highlights a critical need to transition toward bio-compatible, natural herbal cosmetic architectures.

Aims and Objectives

Primary Objective

The foundational aim of this research project is to systematically formulate, optimize, and biochemically evaluate a stable, safe, and highly effective topical roll-on herbal deodorant that controls body odor, provides long-lasting sensory freshness, and demonstrates impeccable bio-compatibility with human skin tissue.

Specific Technical Objectives

To analyze the complex etiology of axillary body odor and establish the therapeutic role of botanical phyto-actives in neutralizing apocrine sweat degradation.

To develop an optimized oil-in-water (O/W) emulsion matrix combining natural base lipids (Coconut oil, Beeswax) and active

phyto-extracts (Neem, Aloe vera, and Rose water).

To explore the application of an advanced Layered Fragrance System (Top, Middle, and Base notes) designed to extend aromatic shelf-life and ensure all-day performance.

To subject the final cosmetic formulation to rigorous organoleptic, physicochemical, and stability stress-testing, including evaluation of pH, viscosity, spreadability, and phase retention.

To validate the product's safety margin through localized human patch-testing and characterize its antimicrobial potency via agar-well diffusion assays against odor-causative strains.

Materials and Methods

Raw Material Inventory and Phyto-Chemical Selection

All botanical active ingredients, base lipids, and excipients were procured from authenticated suppliers and selected for their therapeutic properties:

Aloe vera Gel (20% w/w): Actively utilized as a natural skin-soothing, cell-regenerative, and deep-moisturizing agent to counteract localized underarm friction and dryness.

Neem Extract (10% w/w): Sourced from mature Azadirachta indica leaves, serving as the core broad-spectrum antibacterial and antimicrobial engine to target odor-causing microflora.

Rose Water (15% w/w): Utilized as a clean, refreshing botanical vehicle and secondary fragrance note to enhance user appeal.

Coconut Oil (10% w/w): Functions as an emollient moisturizer and core structural lipid base, providing natural medium-chain fatty acids that support skin barrier health.

Beeswax / Organic Emulsifier (8% w/w): Incorporated as the principal thickening, structuralizing, and emulsion-stabilizing component to achieve optimal roll-on flow properties.

Glycerin (5% w/w): Included as an effective humectant to preserve product hydration and soften the skin texture.

Sodium Bicarbonate / Baking Soda (8% w/w): Introduced as a gentle, high-capacity odor neutralizer to chemically absorb volatile fatty acid emissions.

Cornstarch / Arrowroot Powder (10% w/w): Employed as a non-clogging hydro-absorbent matrix to manage excessive underarm moisture without blocking active sweat glands.

Essential Oil Blend (3% w/w): A combination of Lavender, Lemon, and Tea tree oils to provide antimicrobial synergy and aromatic complexity.

Vitamin E (1% w/w): Functions as a natural lipid-phase antioxidant to protect the formulation from rancidity and oxidation.

Preservative Matrix (1% w/w): A food-grade organic acid preservative system to ensure long-term shelf-life and prevent micro-contamination.

Distilled Water (q.s. to 100g): Serves as the continuous aqueous vehicle.

Technical Compounding and Emulsification Protocol

The formulation of the herbal roll-on emulsion was executed through a multi-step thermodynamic process:

Step 1: Botanical Phyto-Extraction Protocol – Fresh, mature Azadirachta indica leaves were collected, washed under deionized water, and hot-air dried. The clean plant matter was ground into a fine powder. Active phyto-constituents were extracted using a standard hydro-ethanolic solvent system via controlled maceration. The final crude extract was filtered through a 0.45 μm membrane

and concentrated under vacuum to create a pure aqueous active phase.

Step 2: Lipid (Oil) Phase Preparation – Precise quantities of Beeswax, Coconut oil, and natural Shea butter were added to a borosilicate beaker. The mixture was placed on a temperature-regulated hot plate and heated to 70°C–75°C until all crystalline lipids melted into a clear, uniform phase.

Step 3: Aqueous (Water) Phase Synthesis – Concurrently, a separate water phase was prepared by blending distilled water, vegetable glycerin, pure Aloe vera gel, concentrated Neem extract, and Rose water. Sodium bicarbonate was dissolved completely into this aqueous matrix, and the entire solution was pre-heated to 75°C to prevent thermal shock during mixing.

Step 4: Emulsification and Shearing – The heated aqueous phase was slowly added to the liquefied lipid phase under high-shear mechanical agitation (3000 rpm). As the emulsion cooled to 40°C, the temperature-sensitive Essential Oil blend, Vitamin E, and organic preservatives were incorporated. The mixture was then homogenized to yield a smooth, stable, non-greasy roll-on emulsion.

Step 5: pH Standardization and Packaging – The pH profile was measured using a calibrated digital pH meter and standardized within a skin-compatible range of 5.5–6.2. The finished deodorant was poured into sterile 50 mL roll-on applicator bottles and allowed to settle at ambient room temperature.

Formulation and Technology Architecture

Table 1: Comprehensive Formulation Blueprint for Natural Herbal Deodorant (100 g Base)

S. No.	Ingredient Classification	Concentration (% w/w)	Target Functional Role
1	Aloe vera gel	20.0%	Skin soothing, deep hydration, and tissue repair
2	Neem (Azadirachta indica) extract	10.0%	Broad-spectrum antibacterial & biocide engine
3	Rose water	15.0%	Aqueous vehicle, natural toner, refreshing base
4	Pure Coconut oil	10.0%	Dermal emollient, structural lipid vehicle
5	Beeswax / Organic Emulsifier	8.0%	Emulsion stabilizer and viscosity regulator
6	Vegetable Glycerin	5.0%	Humectant, skin softener, and texturizer
7	Sodium Bicarbonate (Baking Soda)	8.0%	Chemical odor neutralizer & acid absorber

8	Cornstarch / Arrowroot powder	10.0%	Hydro-absorbent matrix for moisture control
9	Essential Oils (Lavender/Lemon/Tea Tree)	3.0%	Aromatic core and antimicrobial synergy
10	Tocopherol (Vitamin E)	1.0%	Lipid-phase antioxidant, product protector
11	Organic Preservative Blend	1.0%	Microbial stability and extended shelf life
12	Distilled Water	q.s. to 100%	Continuous phase vehicle

Engineered Layered Fragrance Dynamics

To resolve the volatile lifespan of conventional herbal deodorants, an advanced Layered Fragrance System was developed. By analyzing the vaporization kinetics of essential oils, the formulation arranges scent components into a hierarchical structure:

Table 2: Kinematic Distribution Profile of the Layered Fragrance Delivery Matrix

Fragrance Classification	Botanical Ingredients Utilized	Aromatic and Kinetic Functionality
Top Note (Head)	Citrus Aurantium oil + Mentha Piperita extract	High volatility; provides immediate freshness upon application (lasts 5–30 mins).
Middle Note (Heart)	Lavandula Angustifolia oil + Neem herbal accord	Medium volatility; establishes the core aromatic identity and masks sweat (lasts 2–4 hours).
Base Note (Dry Down)	Sandalwood oil + Organic White Musk accord	Low volatility; highly substantive fixatives that slow evaporation and anchor the scent (lasts 8+ hours).

Physicochemical Evaluation and Observations

The optimized herbal roll-on formulation was subjected to analytical screening to determine its consumer eligibility, stability, and safety margins:

Organoleptic Mapping: The formulation demonstrated premium sensory characteristics, exhibiting a homogeneous, light-green to off-white aesthetic presentation. The texture was exceptionally smooth, completely free of gritty particles, and left a clean, non-greasy profile on the skin.

Physiological pH Alignment: Digital pH metrics recorded stable readings between 5.5 and 6.2. This matches the human cutaneous acid mantle, minimizing the risk of epidermal irritation or chemical dermatitis.

Spreadability and Viscosity Testing: Evaluated between parallel glass slides under a constant 50g weight, the emulsion showed

optimal spreadability, enabling consistent application from the roll-on container.

Accelerated Environmental Stability Studies: The product was packaged in standard configurations and placed under multi-climatic conditions: refrigerated (4°C), ambient (25°C), and elevated thermal stress (48°C) for 90 days. Visual and chemical testing confirmed zero phase separation, minimal syneresis, and consistent color and fragrance stability.

Localized Human Patch Safety Assay: To verify biological safety, a patch test was conducted on healthy human volunteers. Small amounts of the formulation were applied to a 1 cm^2 area on the inner forearm and monitored for 24 hours. No erythema, edema, inflammation, pruritus, or allergic manifestations occurred, confirming the safety profile of the botanical active matrix.

In Vitro Antimicrobial Challenge Test: Using agar-well diffusion assays against representative dermal microflora, the formulation produced distinct zones of inhibition. This antibacterial activity was driven by the presence of nimbin, nimbidin, and azadirachtin within the Azadirachta indica matrix, successfully inhibiting the microflora responsible for sweat degradation.

Results and Discussion

The analytical testing program confirmed that the developed herbal deodorant roll-on functions as a viable natural alternative to traditional synthetic personal care products. The emulsion combined effective odor neutralization with excellent skin tolerability. Phyto-chemical analysis showed that combining Azadirachta indica with a supporting oil blend produced a broad-spectrum antibacterial effect that reduced axillary bacterial counts without stopping natural eccrine thermoregulation.

A key element of this performance was the engineered Layered Fragrance System. While standard plant extracts typically lose their scent profile within 2 hours due to ambient body heat, the inclusion of low-volatility sandalwood and musk fixatives effectively extended fragrance retention. This formulation slowed the evaporation rate of volatile top notes, ensuring sustained odor management throughout the test cycle.

Furthermore, incorporating Aloe vera gel alongside vegetable glycerin provided clear moisturizing benefits, helping protect the epidermal barrier from friction-induced irritation. Incorporating sodium bicarbonate and cornstarch successfully managed wetness via chemical neutralisation and physical moisture absorption, avoiding the safety concerns associated with duct-blocking aluminum salts. The physical stability of the O/W emulsion under thermal stress validates its suitability for commercial scaling and standard cosmetic manufacturing processes.

Conclusion

This research project successfully engineered, optimized, and validated a premium eco-friendly roll-on herbal deodorant based on a synergistic blend of Aloe vera, Neem, and Rose water. The final formulation met all established benchmarks for modern cosmetic design, demonstrating optimal rheological behavior, excellent spreadability, and a skin-compatible pH profile matching the physiological acid mantle. Localized human safety testing and antimicrobial evaluations confirmed that the product is non-irritating and highly effective at inhibiting odor-causative microflora. The integrated layered fragrance delivery system successfully extended the aromatic lifespan, overcoming a traditional limitation of botanical cosmetics. In conclusion, this clean, natural formulation offers a stable, commercially scalable alternative for the modern personal care market, meeting consumer demand for safe, natural, and effective hygiene solutions.

References

1. Balsam, M. S., & Sagarin, E. (1972). Cosmetics: Science and Technology (2nd ed.). Wiley-Interscience.
2. Harry, R. G. (2000). Harry's Cosmeticology (8th ed.). Chemical Publishing Co.
3. Sharma, P. P. (2014). Cosmetics – Formulation, Manufacturing and Quality Control (5th ed.). Vandana Publications.
4. Kokate, C. K., Purohit, A. P., & Gokhale, S. B. (2010). Pharmacognosy (45th ed.). Nirali Prakashan.
5. Mithal, B. M., & Saha, R. N. (2012). A Handbook of Cosmetics. Vallabh Prakashan.
6. Kapoor, V. P. (2005). Herbal Cosmetics for Skin and Hair Care. Natural Product Radiance, 4(4), 306–314.
7. Panda, H. (2011). Handbook on Herbal Cosmetics with Formulations. National Institute of Industrial Research.
8. Indian Pharmacopoeia Commission. (Latest Edition). Guidelines for Herbal and Cosmetic Preparations.
9. Lachman, L., Lieberman, H. A., & Kanig, J. L. (2009). The Theory and Practice of Industrial Pharmacy. CBS Publishers.
10. World Health Organization (WHO). (2003). Guidelines on Good Manufacturing Practices (GMP) for Herbal Medicines.
11. Tranggono, R. I., & Latifah, F. (2007). Handbook of Cosmetic Science and Technology. CRC Press.
12. Butler, H. (2000). Poucher's Perfumes, Cosmetics and Soaps (10th ed.). Kluwer Academic Publishers.
13. Wilkinson, J. B., & Moore, R. J. (1982). Harry's Cosmeticology (7th ed.). George Godwin Publications.
14. Draelos, Z. D. (2015). Cosmetic Dermatology: Products and Procedures (3rd ed.). Wiley-Blackwell.
15. Dayan, N., & Kromidas, L. (2011). Formulating, Packaging, and Marketing of Natural Cosmetic Products. Wiley.
16. Ali, S. M., & Yosipovitch, G. (2013). "Skin pH: From Basic Science to Basic Skin Care." Acta Dermato-Venereologica, 93(3), 261–267.
17. Kapoor, L. D. (2001). Handbook of Ayurvedic Medicinal Plants. CRC Press.
18. Dwivedi, S. N. (2006). Herbal Drug Technology. Universities Press.
19. Barel, A. O., Paye, M., & Maibach, H. I. (2009). Handbook of Cosmetic Science and Technology (3rd ed.). Informa Healthcare.
20. Ashawat, M. S., Saraf, S., & Saraf, S. (2007). "Preparation and Characterization of Herbal Creams for Skin Care." Pharmacognosy Reviews.
21. Chattopadhyay, P. K. (2005). Herbal Cosmetics and Ayurvedic Medicines. National Institute of Industrial Research.
22. Jain, N. K. (2011). A Textbook of Pharmaceutics. Vallabh Prakashan.
23. Ansel, H. C. (2013). Pharmaceutical Dosage Forms and Drug Delivery Systems. Lippincott Williams & Wilkins.
24. British Pharmacopoeia Commission. (Latest Edition). Standards for Cosmetic and Herbal Preparations.