

Analytical Evaluation of Herbal and Active Antimicrobial Dermatological Creams

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ABSTRACT

To attempt to confirm active ingredient concentrations and structural base compositions against stated label claims and Indian Pharmacopoeia standards, this study assessed three different commercial topical preparations: a polyherbal cosmetic cream, a quadruple-active antimicrobial/corticosteroid cream, and a 2% ketoconazole antifungal cream. Validated HPLC and spectrophotometric techniques were used. While the quadruple combination cream (Ciprofloxacin 1.02%, Metronidazole 0.998%, Terbinafine Hydrochloride 0.992%, Clobetasol Propionate 0.0502%) and the ketoconazole cream (2.02% w/w) both fell strictly within standard statutory limits of nominal potency, the polyherbal formulation showed complete compliance across all base excipient parameters. In order to ensure product safety, therapeutic efficacy, and batch-to-batch consistency, strict post-market quality assurance is essential.

Keywords: Topical Formulations, Cosmetic Chemistry, Quality Assurance, Active Pharmaceutical Ingredients

INTRODUCTION

Topical dermatological preparations, which include both functional cosmetic formulations and active therapeutic dermatological creams, require precise and highly reproducible ingredient proportioning to ensure long-term physicochemical stability, dermatological safety, and targeted clinical efficacy [1, 2]. In clinical dermatology, complicated polymicrobial or severe inflammatory cutaneous diseases, such as infected eczematous lesions, severe intertrigo, folliculitis, and mixed dermatophytic skin infections, sometimes require multi-component topical therapy [3]. Recent improvements in topical formulation technology have highlighted the need of striking a compromise between vehicle composition and multi-active stability in order to achieve optimum drug penetration while maintaining barrier integrity [4]. For mixed cutaneous infections when bacterial, fungal, and inflammatory diseases coexist, broad-spectrum combination topical formulations containing Ciprofloxacin, Clobetasol Propionate, Metronidazole, and Terbinafine Hydrochloride are commonly recommended [3, 5]. Every active pharmaceutical ingredient (API) performs a unique and complementary pharmacological function.

Ciprofloxacin is a broad-spectrum fluoroquinolone antibiotic that directly inhibits bacterial DNA gyrase (topoisomerase II) and topoisomerase IV to stop bacterial DNA replication and transcription [5]. Although strict concentration control is necessary to avoid localised tissue damage and sub-therapeutic exposure, it has quick bactericidal efficacy against common Gram-positive and Gram-negative cutaneous infections [6]. Clobetasol Propionate is a highly strong corticosteroid that quickly reduces local erythema, oedema, inflammation, and pruritus through immune suppression and vasoconstrictive molecular mechanisms [7]. Because of its high potency, strict quantitative limits (usually between 0.045% and 0.055% w/w) are required to avoid significant systemic absorption, hypothalamic-pituitary-adrenal (HPA) axis suppression, skin atrophy, or striae formation [8]. Metronidazole is a nitroimidazole synthetic anti-infective that breaks bacterial and protozoal DNA, causing double-strand DNA breakage and fast cell death in sensitive anaerobic and microaerophilic species [5]. Its co-formulation in topical matrices has specific activity against anaerobic microbial species seen in polymicrobial cutaneous ulcers and papulopustular dermatoses [9]. Topical imidazole antifungals, such as ketoconazole (2% w/w), continue to be the principal first-line treatments for superficial cutaneous mycoses, pityriasis versicolour, and seborrhoeic dermatitis [5]. Topical treatment allows highly localised drug distribution precisely inside affected epidermal layers while minimising systemic absorption, hence eliminating systemic oral hepatotoxicity concerns and drug-drug metabolic interactions [5].

Despite the implementation of stringent international regulatory frameworks, such as the European Union Cosmetic Regulation (EC) No. 1223/2009, the United States Food and Drug Administration (US FDA) cGMP rules, and the Indian Drugs and Cosmetics Rules, post-market surveillance and routine quality evaluations continue to reveal instances of mislabeled, substandard, or adulterated products [10, 11, 12]. Commercial creams with complex biphasic matrices (water-in-oil or oil-in-water emulsions) provide significant analytical issues during manufacture, such as phase separation, API degradation, and non-uniform active dispersion [13,14, 15]. Additionally, equivalent analytical integrity is needed in beauty research due to the growing customer desire for polyherbal creams [13]. Delicate structural balances between aqueous phases, lipophilic carrier oils, emulsifier complexes, and preservation systems are essential to herbal formulations [1, 16]. Emulsion creaming, rancidity, or microbiological contamination can result from inadequate emulsifier or preservative proportions, which can cause severe contact allergic dermatitis or localised skin sensitisation [17]. Therefore, thorough quantitative quality control testing is essential to ensure batch-to-batch repeatability, therapeutic performance, and consumer safety by bridging the crucial gap between commercial label claims and actual chemical composition [13, 14].

MATERIALS & METHODS

Three representative manufactured batches, Polyherbal Cosmetic Cream (Sample 1, fill weight 10.2 g), Quadruple Combination Antibiotic/Antifungal/Corticosteroid Cream viz. Ciprofloxacin, Metronidazole, Terbinafine Hydrochloride and Clobetasol cream (Sample 2, fill weight 10.0 g), and Ketoconazole 2% w/w Cream (Sample 3, fill weight 10.1 g), were analysed

for independent quantitative testing in accordance with standard regulatory guidelines. Testing was carried out according to approved Indian Pharmacopoeia (IP 2022) monograph procedures and verified standard testing with the use of spectrophotometric assays and High-Performance Liquid Chromatography (HPLC). Polyherbal Cream Base Analysis: The aqueous content, lipid/wax content, botanical active fraction, emulsifier concentration, and preservative levels were measured. Ciprofloxacin HCl, Metronidazole Benzoate, Terbinafine HCl, and Clobetasol Propionate were measured using the validated chromatographic separation technique in the quadruple active cream assay. Assay for Ketoconazole: carried out strictly in compliance with the official IP 2022 monograph standards.

RESULTS AND DISCUSSION

All tested topical formulations met their individual label claims and pre-established quality standards. The Polyherbal Cosmetic Cream (Sample 01) was evaluated and all structural emulsion constituents and botanical actives fell within defined limits: the water phase yielded 61.7% (spec: 50.0%-70.0%), oils and waxes tested at 12.3% (spec: 10.0%-20.0%), herbal actives were present at 5.6% (spec: 2.0%-10.0%), emulsifiers measured 4.1% (spec: 3.0%-6.0%), and preservative levels were at 0.26% (spec: 0.2%-1.0%) (Table 1). Quantitative assays for the Quadruple Active Cream (Sample 02) showed active pharmaceutical ingredient (API) recovery values between 99.2% and 102.0% of nominal label claims, with Ciprofloxacin HCl at 1.02% (claim: 1.00%; acceptance range: 0.90%–1.10%), Metronidazole Benzoate at 0.998% (claim: 1.00%; acceptance range: 0.90%–1.10%), Terbinafine HCl at 0.992% (claim: 1.00%; acceptance range: 0.90%–1.10%), and Clobetasol Propionate at 0.0502% (claim: 0.05%; acceptance range: 0.045%–0.055%) (Table 1). Finally, monograph assay testing for Ketoconazole 2% Cream (Sample 03) yielded an active content of 2.02% w/w, satisfying the required 1.80%–2.20% acceptance range in compliance with IP 2022 standards (Table 1).

Table 1: Analytical Assay: Herbal Cream Formulation (Sample 01)

Parameter Component	Test Result (%)	Declared Claim Range (%)	Permissible Limits (%)
Water Phase	61.7%	50.0% – 70.0%	50.0% – 70.0%
Oils & Waxes	12.3%	10.0% – 20.0%	10.0% – 20.0%
Herbal Actives	5.6%	2.0% – 10.0%	2.0% – 10.0%
Emulsifiers	4.1%	3.0% – 6.0%	3.0% – 6.0%
Preservatives	0.26%	0.2% – 1.0%	0.2% – 1.0%

Table 2: Analytical Assay: Quadruple Active Cream (Sample 02)

Active Ingredient	Assay Result (%)	Label Claim (%)	Acceptance Range (%)
Ciprofloxacin HCl (as HCl)	1.02%	1.00%	0.90% – 1.10%

Metronidazole (as Benzoate)	0.998%	1.00%	0.90% – 1.10%
Terbinafine HCl	0.992%	1.00%	0.90% – 1.10%
Clobetasol Propionate	0.0502%	0.05%	0.045% – 0.055%

Table 3: Analytical Assay: Ketoconazole 2% Cream (Sample 03)

Parameter	Assay Result (%)	Label Claim (%)	Acceptance Range (%)
Ketoconazole Assay	2.02%	2.00%	1.80% – 2.20%

The structural integrity and long-term thermodynamic stability of topical emulsion systems depends significantly on precise phase ratios and interfacial tension management [18, 19]. The analysed polyherbal cream base strictly followed established cosmetic formulation criteria, utilising an aqueous phase (61.7%) to optimise vehicle hydration, cooling effects, and dermatological spreadability [20], coupled with a balanced lipophilic phase (12.3%) [21] and an emulsifier surfactant complex (4.1%) [14]. This precise ratio preserves kinetic stability by avoiding physical instability events as creaming, coalescence, or phase separation with time [22, 23]. The simultaneous quantification of chemically diverse active pharmaceutical ingredients—specifically fluoroquinolones (Ciprofloxacin HCl), imidazoles (Metronidazole Benzoate), allylamines (Terbinafine HCl), and potent corticosteroids (Clobetasol Propionate)—presents significant analytical challenges for multi-component therapeutic topical formulations due to varying polarities, degradation pathways, and potential excipient matrix interference [24, 25]. The strict alignment of observed chromatographic recovery values with target values (99.2%-102.0%) demonstrates technique selectivity, robustness, and precise batch-to-batch dosing in commercial production.

This level of quantitative precision is therapeutically significant in fixed-dose combo treatments. Sub-potent active levels may result in sub-therapeutic exposure, which can accelerate the development of antimicrobial resistance or lead to clinical treatment failure [7, 26]. In contrast, super-potency raises the likelihood of local systemic absorption and unfavourable cutaneous responses, such as corticosteroid-induced epidermal atrophy, striae, or allergic contact dermatitis [3, 27]. Adherence to approved reference parameters, as evidenced by the Ketoconazole 2% cream test (2.02% w/w), enhances product safety, chemical stability, and regulatory compliance under current pharmacopeial standards [28].

CONCLUSION

The analytical verification of commercial topical cosmetic and pharmaceutical formulations revealed strict conformance to claimed standards and pharmacopoeial quality restrictions. Using validated chromatographic and spectrophotometric methods, all three representative test samples—a polyherbal cream base, a quadruple-component combination cream, and a 2% ketoconazole monograph formulation—met their predefined acceptance criteria with high

quantitative accuracy. These findings support the structural integrity, homogeneous distribution of active pharmaceutical ingredients (APIs), and manufacturing consistency necessary for complicated topical dosage forms. Routine, rigorous quality control testing is still necessary to guarantee continuing formulation stability, prevent therapeutic failure or adverse cutaneous effects, ensure patient safety, and maintain consumer trust in commercial healthcare products.

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