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Terminalia arjuna Bark Extract and Coenzyme Q10 in Biotex COQ10 Cream: Antioxidant, Bioenergetic and Barrier Evidence in Skin Ageing — A Critical Narrative Review

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Abstract: Skin ageing reflects intrinsic biological change together with cumulative environmental exposure. Oxidative stress, mitochondrial dysfunction, impaired epidermal barrier homeostasis and extracellular matrix remodelling contribute to dryness, roughness, loss of elasticity and wrinkle formation. This critical narrative review evaluates the skin-relevant evidence for the two declared formulation components of Biotex COQ10 Cream: *Terminalia arjuna* bark extract and caprylic/capric triglycerides-coenzyme Q10 (CoQ10) powder. Evidence was prioritised by translational relevance, with human topical studies considered before *ex vivo* human-skin, reconstructed epidermis, primary skin-cell, formulation and phytochemical evidence. In a vehicle-controlled human study, *T. arjuna* bark extract lowered water loss across the stratum corneum while raising hydration, smoothing surface scaling and measurably improving skin recoil; parallel cell and tissue work implicated FGF-2, TSP-1, TGF-β, CTGF and VEGF as contributing signals. CoQ10 is an endogenous lipid-soluble electron carrier and antioxidant. Topical studies demonstrate epidermal replenishment, increased ubiquinol, improved cellular energy metabolism, attenuation of oxidative stress, modulation of ultraviolet-associated IL-6/MMP-1 signalling and improvement of wrinkle-related parameters. Caprylic/capric triglycerides are best interpreted as an emollient lipid vehicle that provides a formulation-compatible environment for highly lipophilic CoQ10, with *in vivo* evidence of surface hydration and barrier support in their own right rather than independent anti-ageing activity. Collectively, the literature supports a coherent ingredient-level rationale for antioxidant defence, barrier support, moisture retention, elasticity and a smoother, resilient healthy-ageing appearance, while remaining distinct from direct clinical proof of the finished Biotex formulation.

Keywords: *Terminalia arjuna*; coenzyme Q10; skin ageing; skin barrier; antioxidants; transepidermal water loss; extracellular matrix; topical cosmeceuticals.

Abbreviations

Abbreviation	Definition	Abbreviation	Definition
AP-1	activator protein 1	CCT	caprylic/capric triglycerides
CoQ10	coenzyme Q10	CTGF	connective tissue growth factor
DPPH	2,2-diphenyl-1-picrylhydrazyl	ECM	extracellular matrix
FGF-2	fibroblast growth factor 2	IL-6	interleukin 6

LDH	lactate dehydrogenase	MAPK	mitogen-activated protein kinase
MMP	matrix metalloproteinase	ROS	reactive oxygen species
SDS	sodium dodecyl sulphate	TEWL	transepidermal water loss
TGF-β	transforming growth factor β	TSP-1	thrombospondin 1
UV	ultraviolet	UVA	ultraviolet A
UVB	ultraviolet B	VEGF	vascular endothelial growth factor

1. Introduction

Human skin ages through a combination of genetically programmed intrinsic processes and cumulative extrinsic exposures. Chronological ageing is accompanied by slower epidermal turnover, altered lipid processing, reduced water-holding capacity, fibroblast dysfunction and progressive remodelling of the dermal extracellular matrix (ECM). Extrinsic ageing superimposes environmental stressors—most prominently ultraviolet (UV) radiation, but also air pollution, tobacco smoke, climate and lifestyle factors—on these intrinsic changes. The clinical result is a spectrum that includes xerosis, roughness, uneven texture, reduced elasticity, laxity and wrinkles[1,2]. The concept of the skin ageing exposome is useful because it recognises that visible ageing is not produced by a single pathway, but by repeated interactions among oxidative, inflammatory, metabolic and structural processes[2].

Oxidative stress is a major mechanistic bridge between environmental exposure and structural ageing. UV radiation and other stressors increase reactive oxygen and nitrogen species, which can oxidise membrane lipids, proteins and nucleic acids and can activate redox-sensitive signalling cascades[3,4]. In human skin, these events are closely linked to mitogen-activated protein kinase and activator protein-1 signalling and to increased expression of matrix metalloproteinases (MMPs). MMP-1 initiates cleavage of fibrillar collagens, while other MMPs facilitate further matrix degradation. Repeated activation contributes to collagen fragmentation, impaired mechanical coupling between fibroblasts and matrix, and the characteristic dermal disorganisation of photoaged skin[5-7].

The epidermal barrier changes in parallel. The stratum corneum is a highly organised structure composed of corneocytes embedded within intercellular lipid lamellae. Its capacity to restrict transepidermal water loss (TEWL), maintain hydration and support orderly desquamation is essential for normal surface texture and comfort[8-10]. Ageing can disturb lipid synthesis and processing, stratum corneum acidity, hydration and recovery after barrier challenge[8]. Increased water loss and reduced hydration contribute to scaling, roughness and a less supple appearance, making barrier-directed strategies relevant to both dermatological function and cosmetic ageing.

Mitochondrial biology provides a second important axis. Dermal fibroblasts and epidermal keratinocytes require substantial energy for matrix synthesis, cellular renewal and stress adaptation. Fibroblasts aged in culture reproduce most of the recognised hallmarks of cellular ageing — mitochondrial decline, disturbed proteostasis, accumulated DNA damage and senescence-associated change — although how completely these translate to fibroblasts ageing *in situ* within human skin remains only partly established[11]. Coenzyme Q10 (CoQ10; ubiquinone-10) occupies a distinctive position in this biology because it is both an electron carrier in the mitochondrial respiratory chain and a lipid-phase redox molecule capable of antioxidant activity[12]. Cutaneous CoQ10 is therefore relevant to both bioenergetics and oxidative defence.

Against this mechanistic background, the formulation considered in this review combines *Terminalia arjuna* bark extract with caprylic/capric triglycerides–CoQ10 powder. The scientific rationale is complementary rather than redundant. Arjuna bark provides a triterpenoid- and polyphenol-containing botanical fraction with direct topical evidence for barrier, hydration and elasticity outcomes, whereas CoQ10 provides an endogenous antioxidant and bioenergetic molecule with evidence for epidermal replenishment, oxidative-stress modulation and wrinkle-related pathways. Caprylic/capric triglycerides (CCT) serve principally as a lipid vehicle and emollient environment. The purpose of this review is to critically synthesise these evidence streams and assess how far they support the cosmetic and skin-supportive positioning of Biotex COQ10 Cream without conflating ingredient evidence with finished-product clinical efficacy.

2. Review Methodology

This article was developed as a critical narrative review with structured literature retrieval. Searches were conducted from database inception through 2026. PubMed/MEDLINE was the primary biomedical database, complemented by Scopus, Web of Science, Crossref and targeted Google Scholar/citation chaining for older mechanistic and formulation papers. Search concepts combined terms for *Terminalia arjuna* bark, topical skin outcomes, triterpenes, TEWL, moisturisation, elasticity, fibroblasts, extracellular matrix, coenzyme Q10/ubiquinone, epidermal delivery, photoageing, ultraviolet exposure, MMP-1, keratinocytes, caprylic/capric triglycerides, emollients and topical vehicles.

English-language, peer-reviewed publications were prioritised. Human topical controlled or clinical studies were considered highest in translational relevance, followed by *ex vivo* human-skin penetration studies, reconstructed human epidermis and primary human keratinocyte/fibroblast studies, then topical pharmaceutics and phytochemical/mechanistic studies. Oral CoQ10 trials were not treated as direct evidence for topical efficacy. Evidence from other *Terminalia* species or non-bark plant parts was not treated as specific to *T. arjuna* bark, and CCT evidence was interpreted primarily in relation to vehicle, emollient and safety functions.

The synthesis was organised by biological and cosmetic benefit domain rather than as a chronological catalogue of studies. Formulation identity, comparator, measured endpoint and the distinction between the tested research preparation and the Biotex finished product were considered explicitly. Because the evidence bank was assembled iteratively for a narrative review rather than through a prospectively logged systematic-review workflow, PRISMA-style record counts were not generated and are not reported. This limitation is stated to avoid implying a systematic-search precision that was not part of the review design.

3. Formulation-Centred Scientific Framework

For this review, Biotex COQ10 Cream is treated as a two-component active system comprising (i) *Terminalia arjuna* bark extract (Arjuna extract) and (ii) caprylic/capric triglycerides-CoQ10 powder. No concentration assumptions are made. Within the second component, CoQ10 is regarded as the biologically active ingredient and CCT as the formulation-supporting lipid phase. This avoids the common error of assigning equivalent pharmacological status to an antioxidant active and its carrier. The resulting evidence framework is set out in Table 1.

Table 1. Formulation-evidence framework for Biotex COQ10 Cream.

Declared component	Scientific identity/source	Primary evidence-linked role	Highest relevant evidence level
Arjuna extract	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn. bark/stem-bark extract	Barrier support, reduced TEWL, hydration, surface quality, elasticity, ECM-associated signalling	Human topical controlled data plus reconstructed epidermis/human-cell evidence[13]
Caprylic/Capric Triglycerides–CoQ10 powder	CoQ10 (ubiquinone-10) dispersed/associated with CCT	CoQ10: antioxidant defence, mitochondrial bioenergetics, UV/ROS and MMP-related pathways. CCT: lipid vehicle, emollience and skin conditioning	Human topical/*ex vivo* CoQ10 evidence[14-17]; cosmetic safety/function evidence for triglycerides[18]

Abbreviations: CCT, caprylic/capric triglycerides; CoQ10, coenzyme Q10; ECM, extracellular matrix; TEWL, transepidermal water loss.

The central working model is therefore an evidence-convergence model: Arjuna bark extract contributes primarily to epidermal barrier function, moisture retention and skin biomechanics, while CoQ10 contributes primarily to redox balance, cellular energy metabolism and photoageing-related signalling. Their combination is scientifically plausible because barrier integrity and oxidative/bioenergetic homeostasis are interdependent determinants of skin quality, even though direct synergism between these two ingredients has not been clinically demonstrated in the finished product.

3.1 Biotex COQ10 Cream: Product Context and Formulation Rationale

Biotex COQ10 Cream is the finished topical cream that provides the product-level context for this review. The manuscript evaluates the scientific rationale of the declared ingredient architecture rather than assuming that evidence generated with other topical preparations constitutes direct clinical proof of the finished Biotex product. This distinction is maintained throughout the review to keep product interpretation aligned with the highest available evidence tier.

Product name: Biotex COQ10 Cream. Dosage form: Topical cream. Evidence-reviewed formulation components: *Terminalia arjuna* bark extract and caprylic/capric triglycerides-CoQ10 powder. Ingredient concentrations: Not stated in this review. Product-specific clinical evidence: No direct clinical study of the combined finished product was identified in the literature set used for this review.

From a formulation perspective, the product can be interpreted through three complementary roles: *Terminalia arjuna* bark extract provides the barrier-hydration-elasticity and extracellular-matrix evidence stream; CoQ10 provides the antioxidant-bioenergetic-photoageing evidence stream; and caprylic/capric triglycerides provide the lipid vehicle and emollient environment for the lipophilic CoQ10 component. The finished product is shown in Figure 1. The subsequent sections examine each evidence stream separately before integrating them at the finished-product level.

Fig 1: Biotex COQ10 Cream, the finished topical product whose declared ingredient architecture is evaluated in this review. The photograph is included for product identification only and does not itself constitute evidence of clinical efficacy.

4. *Terminalia arjuna* Bark: Botanical Identity and Skin-Relevant Phytochemistry

Terminalia arjuna (Roxb. ex DC.) Wight & Arn. belongs to the Combretaceae family and has a long pharmacognostic history in South Asian medicine. The ingredient relevant to the present formulation is the bark, not the leaf, fruit or root. This distinction matters because the qualitative and quantitative phytochemical profile varies by plant part, extraction solvent, geographic source, harvest conditions and processing. Contemporary bark-focused reviews describe triterpenoids, tannins, flavonoids, glycosides and other phenolic constituents as major classes[19-21].

Pentacyclic triterpenoids are particularly important to the skin narrative because the direct topical study by Farwick and colleagues explicitly investigated triterpenes derived from *T. arjuna* bark[13]. Representative compounds reported from the bark include arjunolic acid, arjunic acid, arjungenin and related triterpenoid derivatives and glycosides[19,22,23]. Arjunolic acid has received broad experimental attention for antioxidant and cytoprotective properties, but it should not be treated as the sole determinant of whole-bark extract activity because clinical topical studies used defined bark preparations rather than isolated arjunolic acid[22,23].

Polyphenols and tannins add a second chemical dimension. Their multiple hydroxyl groups enable redox interactions and radical-scavenging activity, while the broader bark matrix may influence protein interactions and formulation behaviour. These properties make antioxidant activity chemically plausible, but chemical assays such as DPPH should remain subordinate to human skin endpoints in claim interpretation. The most defensible use of phytochemistry is therefore to explain how a bark extract could generate barrier and ECM effects rather than to reverse-engineer every clinical observation to a single molecule.

5. Arjuna Bark Extract and Epidermal Barrier Function

The epidermal permeability barrier is central to dry-skin physiology and to the visible quality of ageing skin. Water retention depends on both hygroscopic material within corneocytes and the integrity of intercellular lipid lamellae. When barrier function deteriorates, TEWL rises, hydration falls, and enzymatic processes required for orderly desquamation become less efficient, contributing to scaling and surface roughness[8-10]. Consequently, TEWL and corneometric hydration are clinically meaningful biophysical endpoints for a topical formulation positioned around moisture retention and skin resilience.

Farwick et al. provide the strongest direct evidence for *T. arjuna* bark in this context. The investigators combined reconstructed human epidermis, cultured human keratinocytes and fibroblasts with controlled topical evaluation. Thirty participants applied either a preparation of the bark extract or a matched vehicle control cream, and barrier, hydration and biomechanical status were captured instrumentally rather than by self-report. Water loss across the stratum corneum fell, hydration and surface smoothness both rose, and the gain in skin elasticity reached statistical significance[13]. These are unusually relevant outcomes because they map directly onto barrier, hydration and biomechanical claim domains rather than relying on surrogate antioxidant assays alone.

The reconstructed epidermis component strengthens the biological interpretation. Exposing the model to an anionic surfactant provoked a rise in lactate dehydrogenase leakage — a conventional readout of membrane and barrier stress — and treating the same tissue with the bark preparation returned that leakage towards baseline[13]. This does not prove repair of damaged human epidermis *in vivo*, but it supports a mechanistic relationship between the tested bark constituents and epidermal resilience. In a cosmetic context, the most defensible translation is that Arjuna bark extract has ingredient-level evidence supporting epidermal barrier function and moisture retention.

6. Arjuna Bark Extract, Hydration, Surface Quality and Elasticity

Hydration is more than a sensory property. Stratum corneum water content affects corneocyte flexibility, enzymatic desquamation and optical surface characteristics. Poor hydration produces a rougher microrelief and visible flaking, whereas improved water retention generally enhances softness and suppleness[9,24,25]. In the Farwick study, the gain in moisturisation was accompanied by a fall in surface scaling[13], supporting an integrated interpretation in which barrier improvement is reflected in visible surface quality.

Elasticity provides a second, deeper dimension of relevance. Ageing skin loses recoil because of changes in collagen architecture, elastin, glycosaminoglycans, dermal fibroblast function and hydration[7]. The significant improvement in instrumentally measured elasticity reported with topical *T. arjuna* bark extract is therefore particularly valuable[13]. Although the study does not establish that the Biotex formulation will reproduce the same magnitude of effect, it provides direct human topical support for language such as “supports skin elasticity” or “helps maintain a supple, firmer-looking appearance.”

A separate cohort of 30 postmenopausal women in the same investigation provides additional context. In that arm, the investigators recorded greater cutaneous microvascular perfusion and sebum output, a denser echographic skin profile, and — on standardised digital photographs — less pronounced slackening along the jawline[13]. These findings should be interpreted carefully: they are evidence for the specific test preparation in an age-defined population and should not be generalised into a universal lifting claim. Nevertheless, they reinforce the conclusion that Arjuna bark triterpenes can affect several measurable parameters associated with aged and dry skin.

7. Arjuna Bark Extract and Extracellular-Matrix-Associated Signalling

The mechanistic arm of the Farwick study evaluated gene and protein responses in human skin-relevant systems. Four matrix-associated mediators — fibroblast growth factor-2 (FGF-2), thrombospondin-1 (TSP-1), transforming growth factor-β (TGF-β) and connective tissue growth factor (CTGF) — were upregulated when the triterpene fraction was applied, and vascular endothelial growth factor (VEGF) was released in greater quantity into the culture medium[13]. These factors participate in fibroblast biology, matrix regulation, cell-matrix communication and tissue-supportive signalling.

The TGF-β/CTGF axis is particularly relevant to dermal homeostasis because ageing and photoageing are associated with impaired TGF-β signalling and reduced collagen biosynthesis in fibroblasts[7]. FGF-2 influences fibroblast behaviour and cellular communication, while TSP-1 can modulate matrix interactions and growth-factor activity. VEGF is more appropriately regarded as a tissue-supportive signalling mediator than as a direct anti-ageing endpoint. The importance of these observations lies in network plausibility: they suggest that Arjuna triterpenes can influence an ECM-related signalling environment, not that the finished cream has been shown to increase these proteins in human users.

This distinction is central to rigorous claim translation. A statement such as "supports pathways involved in matrix homeostasis" is evidence-consistent. By contrast, a statement that the product "boosts collagen through TGF-β" would exceed the available finished-product evidence unless product-specific biomarker studies were performed.

8. Antioxidant and Topical-Formulation Evidence for *Terminalia arjuna*

Topical formulation work by Gaikwad and Jadhav adds pharmaceutical support to the bark-extract literature. Working from a ternary phase diagram, the authors built emulsified systems around the bark extract and put them through a full pharmaceutical characterisation — secondary-metabolite profiling, solubility mapping, globule size and zeta potential, drug release, radical-scavenging and tyrosinase-inhibition assays, a dermal irritation test in albino rats, and three-month stability storage[26]. Radical scavenging in the DPPH assay was satisfactory, and the emulsions remained physically stable, so the work establishes that Arjuna bark extract can be carried in a stable topical emulsion and supplies a secondary, chemistry-level antioxidant rationale.

However, formulation studies must be graded appropriately. DPPH is a chemical radical-scavenging assay and cannot establish clinical antioxidant efficacy in human skin. Similarly, anti-tyrosinase findings provide mechanistic context but do not by themselves justify a finished-product pigmentation or depigmentation claim, and the irritation testing was conducted in rodents rather than in human volunteers. In the present review, the formulation study is therefore used to support topical feasibility and antioxidant plausibility, whereas the Farwick human data remain the anchor for barrier, hydration and elasticity claims. The evidence tiers are summarised schematically in Figure 2, and the underlying Arjuna studies are listed in Table 2.

Table 2. Key *Terminalia arjuna* bark evidence relevant to topical skin care.

Study	Model/preparation	Key endpoints	Main findings	Review interpretation
Farwick et al. (2014)[13]	Reconstructed epidermis; human keratinocytes/fibroblasts; vehicle-controlled topical studies	TEWL, moisturisation, scaliness, elasticity; FGF-2, TSP-1, TGF-β, CTGF, VEGF	Water loss across the stratum corneum and surface scaling both fell; hydration rose, and the elasticity gain was statistically significant; supportive ECM-related signalling *in vitro*	Primary direct human topical anchor for barrier, hydration and elasticity claims (vehicle-controlled, 30 participants)
Gaikwad & Jadhav (2019)[26]	Emulsified topical *T. arjuna* formulations	Phytochemistry, stability, *ex vivo* permeation, DPPH antioxidant assay, anti-tyrosinase activity, irritation	Established topical formulation feasibility and three-month physical stability, with satisfactory radical scavenging in a chemical assay; irritation testing was in albino rats	Supports topical feasibility and antioxidant plausibility; not clinical efficacy
Kumar et al. (2023)[19]	Bark-focused review	Bark phytochemistry and pharmacological context	Summarises triterpenoids, polyphenols and other bark constituents	Supports botanical/phyto chemical context; lower translational level for skin claims

Abbreviations: CTGF, connective tissue growth factor; FGF-2, fibroblast growth factor 2; TEWL, transepidermal water loss; TGF-β, transforming growth factor β; TSP-1, thrombospondin 1; VEGF,

vascular endothelial growth factor. DPPH is a chemical antioxidant assay and is not equivalent to clinical antioxidant efficacy.

Fig 2: Evidence-linked cutaneous actions of *Terminalia arjuna* bark extract. Direct human topical outcomes include reduced transepidermal water loss, improved moisturisation, reduced scaliness and increased elasticity. Mechanistic and reconstructed-epidermis observations include FGF-2, TSP-1, TGF-β, CTGF and VEGF signalling together with barrier-recovery responses. The two evidence tiers are presented separately to distinguish direct human outcomes from mechanistic support.

9. Coenzyme Q10: Chemistry, Endogenous Function and Cutaneous Relevance

Coenzyme Q10 is a lipid-soluble 1,4-benzoquinone containing a long isoprenoid side chain. In its oxidised form, it is referred to as ubiquinone, while the reduced form, ubiquinol, is an important lipid-phase antioxidant. CoQ10 is synthesised endogenously and is present in cellular membranes and mitochondria. Within the mitochondrial electron-transport chain, it transfers electrons from complexes I and II toward complex III, contributing to proton-gradient formation and ATP synthesis[12]. Its redox cycling additionally enables antioxidant activity in lipid environments.

These dual functions are directly relevant to skin ageing. Keratinocytes require energy for differentiation, barrier maintenance and stress responses, while fibroblasts require energy for matrix synthesis and repair. Fibroblasts aged in culture show mitochondrial decline alongside other hallmarks of cellular ageing, with the *in situ* picture in human skin less fully characterised[11]. At the same time, skin is exposed to high oxidative burden from UV radiation and environmental stress. A molecule that participates in both energy metabolism and antioxidant defence therefore occupies a mechanistically coherent position in topical skin care.

A recent dermatology-focused review drew these threads together, concluding that the skin's own CoQ10 reserve is depleted both by chronological ageing and by external stressors, and that applying the molecule topically restores those reserves and improves age-related surface changes[27]. As with any ingredient review, industry involvement in much of the CoQ10 literature should be recognised, but the core conclusions are supported by multiple experimental approaches, including direct human topical sampling, *ex vivo* human skin penetration and cell-based redox and energy measurements.

10. Topical Delivery and Epidermal Replenishment of CoQ10

The principal formulation challenge for CoQ10 is its pronounced lipophilicity and poor aqueous solubility. Topical efficacy depends not merely on adding CoQ10 to a cream but on achieving adequate distribution within the stratum corneum and viable epidermis. Hoppe et al. showed that CoQ10 applied to the skin surface did not remain there: it was recovered from living epidermal tissue, and treated sites returned a lower oxidation signal on weak-photon-emission measurement[14]. This early study established the key concept that CoQ10 can move beyond the skin surface under appropriate formulation conditions.

Knott et al. later provided a more detailed topical replenishment analysis. Seventy-three volunteers applied a Q10 cream or a more concentrated Q10 serum twice daily for two weeks; sampling of both the skin surface and suction-blister epidermis showed higher quinone content at each depth, with the serum producing the larger rise. Ubiquinol, the reduced and antioxidant-competent form, also increased —

significantly so only with the stronger formulation — which the authors interpreted as partial *in situ* conversion of the delivered ubiquinone[16]. The translational step followed: keratinocytes dosed with 18 μM Q10, the concentration calculated to match treated epidermis, raised their oxygen-consumption rate from 2.79 to 3.84 fmol/min per cell on extracellular-flux analysis[16]. This creates a bridge from topical deposition to a directly measured cellular function.

Ex vivo human-skin research by Tessema et al. reinforces the formulation-dependence of penetration. Using a validated HPLC method on sequential slices of excised human skin, the authors compared a lecithin-based microemulsion with a conventional hydrophilic cream. The cream, not the microemulsion, delivered the highest CoQ10 concentration to the viable epidermis — the layer the molecule needs to reach — an outcome the authors ascribed to the 10% 2-ethylhexyl laurate it contained acting as a penetration enhancer[17]. Two lessons follow for product interpretation. A conventional cream base is not intrinsically inferior to a nanostructured vehicle for this active; and, conversely, delivery is governed by the specific excipients present rather than by the dosage form alone, so equivalence between published vehicles and the Biotex formulation should not be presumed.

11. CoQ10, Mitochondrial Bioenergetics and Cellular Homeostasis

Mitochondrial impairment is increasingly recognised as a component of cutaneous ageing and photoageing. Reduced respiratory efficiency can increase oxidative stress, alter cellular redox status and impair energy-demanding repair processes[11,12]. CoQ10 is indispensable for electron transfer within oxidative phosphorylation, so adequate availability is mechanistically linked to mitochondrial function[12].

The Knott study provides direct skin-relevant evidence for this concept. Human keratinocytes exposed to the Q10 concentration measured in the epidermis after topical use consumed significantly more oxygen than untreated controls, consistent with augmented energy metabolism[16]. This observation is more informative than generic statements that CoQ10 “energises” skin. The scientifically appropriate interpretation is that topical CoQ10 can replenish epidermal quinone levels and that comparable intracellular exposure can increase a mitochondrial bioenergetic parameter in human keratinocytes.

This bioenergetic pathway complements the antioxidant pathway. During electron transfer, ubiquinone can be reduced to ubiquinol; the latter can protect membrane lipids and other targets from oxidation[12]. Thus, CoQ10 is not simply a scavenger added from outside the cell but part of an integrated redox-energy system. This dual role is one of the strongest mechanistic rationales for its inclusion in age-supportive topical formulations.

12. CoQ10 as a Cutaneous Antioxidant

Oxidative stress in skin results when reactive-species generation exceeds local antioxidant capacity. UV exposure can promote oxidative damage to lipids, proteins and DNA and can amplify inflammatory and MMP-related signalling[3,4,6]. CoQ10, particularly in its reduced ubiquinol form, can intercept lipid-phase radical processes and participate in antioxidant networks[12].

In the Hoppe series, keratinocytes carrying a CoQ10 load withstood UVA better on two independent readouts — their thiol pool was less depleted, and they accumulated less oxidative DNA damage — while fibroblasts exposed to the same irradiation transcribed less collagenase when CoQ10 was present[14]. Knott et al. added a tissue-level counterpart: among volunteers whose untreated skin already registered elevated oxidative stress, two weeks of Q10 application both lowered the free-radical reading of suction-blister fluid and raised its antioxidant-defence capacity[16]. Taken together, these findings support a genuine cutaneous antioxidant role rather than a purely chemical antioxidant label, although both reports originate from the same corporate research group, a source-independence limitation revisited in Section 18.

The correct cosmetic interpretation is nonetheless bounded. Antioxidant support does not replace sunscreen and should not be framed as a claim that the cream prevents UV injury in the manner of an approved photoprotective product. The more defensible language is that topical CoQ10 supports cutaneous antioxidant defence and helps counter oxidative stress associated with environmental exposure.

13. CoQ10, UV Signalling, IL-6, MMP-1 and Wrinkle Biology

Wrinkle formation is linked to repeated oxidative and inflammatory signalling that increases dermal matrix degradation. UV exposure activates signalling cascades in keratinocytes and fibroblasts, including MAPK/AP-1 pathways, which increase MMP expression and reduce matrix integrity[5,6]. MMP-1 is particularly important because it initiates cleavage of type I and III fibrillar collagen in human skin[5].

Inui et al. examined the relationship between UVB-exposed keratinocytes and fibroblast MMP production. When normal human keratinocytes were irradiated with UVB, the interleukin-6 (IL-6) they

released was lower if CoQ10 was present in the medium. Transferring that conditioned medium onto fibroblasts carried the effect downstream, and MMP-1 output over 24 hours fell correspondingly[15]. This study is valuable because it models epidermal-to-dermal paracrine signalling rather than considering keratinocytes and fibroblasts in isolation.

The same publication reported a clinical component in which a 1% CoQ10 cream applied for five months lowered the wrinkle-score grade assigned by a dermatologist[15]. Hoppe et al. had also reported a reduction in wrinkle depth after topical CoQ10 use[14]. Although formulations and concentrations in these studies cannot be assumed to match Biotex COQ10 Cream, the combination of mechanistic and clinical observations provides moderate-to-strong ingredient-level support for positioning topical CoQ10 around smoother-looking skin and visible age support. The keratinocyte-to-fibroblast signalling model is summarised in Figure 3, and the principal CoQ10 studies are collated in Table 3.

Table 3: Summary of key topical and skin-relevant CoQ10 studies.

Study	Model/preparation	Formulation/vehicle	Key endpoints	Main findings
Hoppe et al. (1999)[14]	Topical human/skin observations plus human keratinocytes and fibroblasts	CoQ10-containing topical formulations	Cutaneous oxidation, epidermal delivery, UVA oxidative injury, collagenase, wrinkle depth	Topical CoQ10 reached viable epidermal layers, reduced oxidative endpoints and UVA-associated collagenase expression; wrinkle-depth improvement was reported.
Inui et al. (2008)[15]	UVB-exposed keratinocytes; fibroblasts exposed to conditioned medium; clinical topical component	CoQ10-containing cream	Keratinocyte IL-6, fibroblast MMP-1, wrinkle score	CoQ10 lowered UVB-induced keratinocyte IL-6 and downstream fibroblast MMP-1; a 1% CoQ10 cream used for five months improved dermatologist-assessed wrinkle score
Knott et al. (2015)[16]	Human topical treatment plus keratinocyte translational experiments	Q10-containing topical formulas	Surface/epidermal ubiquinone and ubiquinol, free-radical signals, oxygen consumption	Epidermal Q10 and ubiquinol rose after 14 days in 73 volunteers (ubiquinol significant only for the higher-strength formula); free radicals fell, and antioxidant capacity rose in stressed skin; keratinocyte oxygen-consumption rate increased from 2.79 to 3.84 fmol/min per cell at 18 μM
Tessema et al. (2020)[17]	Ex vivo human skin	Microemulsions and hydrophilic cream	Layer-specific skin penetration	The hydrophilic cream, not the microemulsion, achieved the highest viable-epidermis CoQ10 concentration, attributed to a penetration-enhancing excipient; delivery tracked

				excipients rather than dosage form
Farboud et al. (2011)[28]	In vitro and *in vivo* topical formulation study	Q10-loaded solid lipid nanoparticle cream	Formulation properties and skin-biophysical outcomes	Prolonged CoQ10 release from the nanoparticle system relative to a simple cream, with improved skin hydration and elasticity in 25 volunteers
Lohan et al. (2015)[29]	Skin-cell / keratinocyte model	Ultra-small lipid nanoparticles containing CoQ10	Cellular delivery and oxidative stress	Labelled carriers were taken up into keratinocyte cytoplasm and radical formation fell by up to 23% versus untreated controls, exceeding conventional carriers
Souza et al. (2023)[30]	Topical-delivery review	Lipid nanoparticle systems	Characterisation and delivery considerations	Synthesised formulation variables relevant to lipid-based topical CoQ10 delivery

Abbreviations: CoQ10, coenzyme Q10; IL-6, interleukin 6; MMP-1, matrix metalloproteinase 1; UVA/UVB, ultraviolet A/B. Findings apply to the tested formulations and should not be assumed to demonstrate equivalent delivery or efficacy of the Biotex finished product.

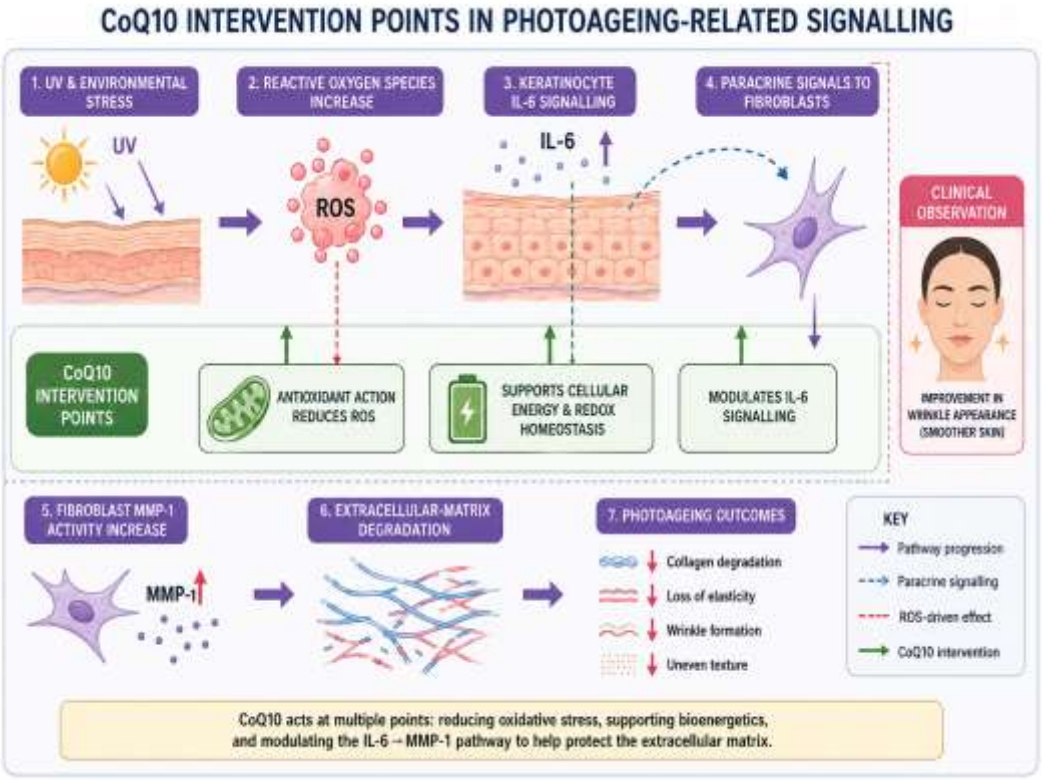

Fig 3: CoQ10 intervention points in photoageing-related signalling. UV and environmental stress increase reactive oxygen species and keratinocyte IL-6 signalling; keratinocyte-derived signals can subsequently increase fibroblast MMP-1 activity and extracellular matrix degradation. CoQ10 is positioned at redox and bioenergetic nodes and at the IL-6-to-MMP-1 paracrine pathway. Clinical wrinkle observations are distinguished from the mechanistic cell-model pathway.

14. Formulation Science of CoQ10 and the Role of Caprylic/Capric Triglycerides

CoQ10 presents a formulation challenge because it is highly lipophilic, poorly water-soluble and susceptible to physicochemical instability. These properties explain the broad research interest in lipid nanoparticles, microemulsions and other delivery systems[17,29,30]. Farboud et al. compared a conventional CoQ10 cream with one carrying the same active in solid lipid nanoparticles, and reported prolonged release from the nanoparticle system together with gains in skin hydration and elasticity among 25 volunteers[28]. Lohan et al. took the question to the cellular level, tracking labelled ultra-small carriers into the cytoplasm of HaCaT keratinocytes and measuring, by electron paramagnetic resonance, a reduction in radical formation of up to 23% relative to untreated controls — a stronger effect than that of the conventional carriers tested alongside[29]. These studies demonstrate the importance of the lipid environment, but they do not establish that any lipid carrier automatically reproduces nanoparticle behaviour.

Caprylic/capric triglycerides are medium-chain triglycerides formed primarily from glycerol esterified with caprylic (C8) and capric (C10) fatty acids. Formulators reach for this class to condition and soften the skin surface, to build viscosity and, less often, to dissolve other ingredients. Reviewing 51 members of the triglyceride family — caprylic/capric triglyceride among them — the Expert Panel for Cosmetic Ingredient Safety judged all of them safe at the concentrations and in the ways they are currently used in cosmetics[18]. CCT therefore has a strong formulation and tolerability rationale.

As an emollient lipid, CCT can improve spreadability, sensory quality and surface conditioning. Its occlusive and emollient behaviour can complement moisturising systems by reducing friction and helping limit surface water loss, although the magnitude of such effects depends on the full emulsion[18,24,25]. Direct *in vivo* support comes from de Souza Neto et al., who applied an emulsion containing 15% caprylic/capric triglyceride to the volar forearm and recorded both a rise in superficial skin hydration and a fall in TEWL, which they attributed to occlusion by the emollient phase; the same emulsion roughly doubled stratum corneum urocanic acid content, although it did not prevent UV-driven isomerisation of that molecule[31]. Lipophilic vehicles can also alter skin partitioning of model

compounds[32,33], but the present evidence does not justify claiming that CCT specifically enhances CoQ10 penetration in Biotex COQ10 Cream. Its most defensible role is as a formulation-compatible lipid vehicle for a lipophilic antioxidant and as an emollient contributor to surface hydration and skin feel.

15. Integrated Mechanistic Rationale for the Arjuna–CoQ10 Combination

The scientific value of the formulation lies in complementary coverage of two major dimensions of skin ageing. Arjuna bark extract is strongest at the barrier–hydration–elasticity interface: its direct topical evidence includes lower TEWL, improved moisturisation, reduced scaliness and improved elasticity, with mechanistic support for ECM-associated signalling[13]. CoQ10 is strongest at the redox–bioenergetic–photoageing interface: topical studies demonstrate epidermal replenishment, increased ubiquinol, enhanced keratinocyte energy metabolism, attenuation of UVA/UVB-associated oxidative and cytokine responses and reduced wrinkle-related parameters[14-17].

These pathways are biologically connected. Barrier impairment can increase sensitivity to environmental stress and worsen surface dryness, while oxidative stress can impair lipids, proteins and cellular repair systems. Conversely, improved barrier function helps maintain a stable epidermal microenvironment, while redox and mitochondrial support can favour cellular homeostasis. The formulation therefore does not require proof of a novel molecular synergy to have a coherent rationale; convergence of independently relevant mechanisms is sufficient to justify a complementary ingredient architecture.

CCT adds a third, formulation-level layer. By providing an emollient lipid environment for CoQ10, it is compatible with the physicochemical requirements of a lipophilic molecule while contributing to spreadability and surface conditioning. The integrated model can therefore be summarised as: Arjuna bark extract for barrier, moisture and elasticity; CoQ10 for antioxidant and bioenergetic support; and CCT for lipid-phase formulation support. This is a more accurate and scientifically useful description than presenting all components as equivalent anti-ageing actives. The integrated ingredient-vehicle model is summarised in Figure 4.

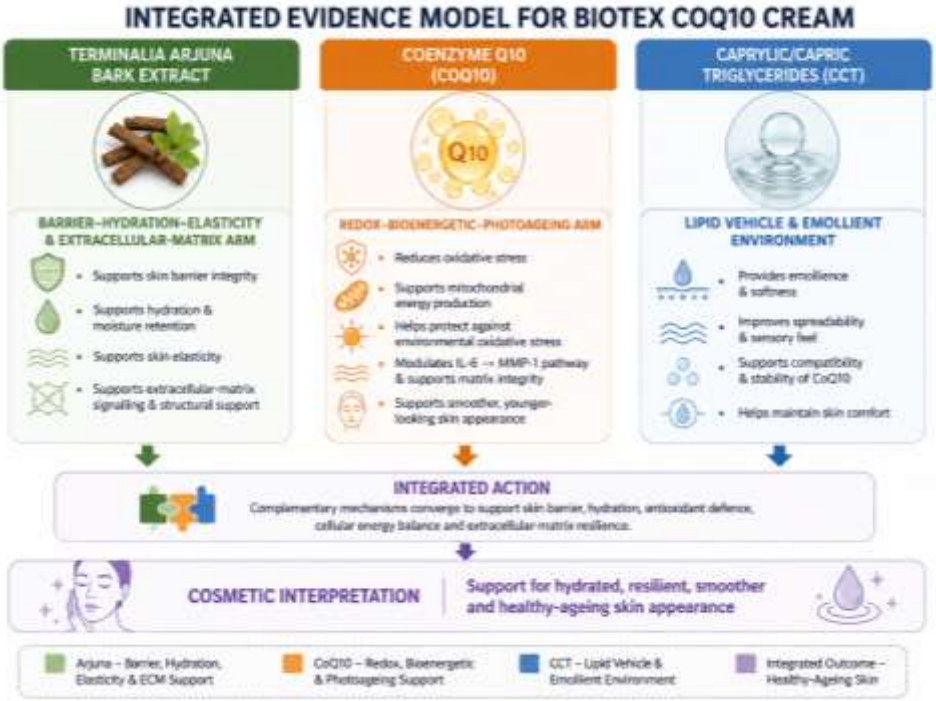

Fig 4: Integrated evidence model for Biotex COQ10 Cream. Terminalia arjuna bark extract represents the barrier-hydration-elasticity and extracellular-matrix arm; CoQ10 represents the redox-bioenergetic-photoageing arm; and caprylic/capric triglycerides are represented separately as the lipid vehicle and emollient environment rather than as a co-equal anti-ageing active. The integrated cosmetic interpretation is support for hydrated, resilient, smoother and healthy-ageing skin appearance.

16. Evidence Appraisal by Cosmetic Benefit Domain

A claim-focused appraisal is useful because different outcomes are supported at different translational levels. The strongest formulation-relevant claims are those where direct human topical evidence exists, particularly Arjuna-associated TEWL, hydration and elasticity and CoQ10-associated epidermal replenishment and wrinkle-related observations. More molecular claims — such as growth-factor modulation, mitochondrial stimulation or MMP reduction — should remain mechanistic descriptors rather than direct finished-product claims. The translational hierarchy used for interpretation is shown in Figure 5, and the domain-by-domain appraisal is set out in Table 4.

Table 4. Evidence appraisal by cosmetic benefit domain.

Benefit domain	Dominant component (s)	Evidence strength	Evidence basis	Recommended scientific wording
Antioxidant defence	CoQ10 + Arjuna	Strong ingredient-level	Topical CoQ10 oxidative-stress data; Arjuna antioxidant/formulation evidence[14,16,26]	Supports cutaneous antioxidant defence and helps counter environmental oxidative stress
Barrier function/moisture retention	Arjuna + CCT	Strong for Arjuna; supportive for CCT	Vehicle-controlled human Arjuna TEWL study; *in vivo* hydration and TEWL data for a 15% CCT emollient emulsion; cosmetic safety and emollient function of triglycerides[13,18,31]	Supports epidermal barrier function and moisture retention
Hydration / reduced dry appearance	Arjuna + CCT	Strong for Arjuna	Human moisturisation and scaliness outcomes for Arjuna; measured rise in superficial hydration with a 15% CCT emulsion[13,31]	Supports hydration, softness and a supple appearance
Elasticity / firmer-looking skin	Arjuna	Strong ingredient-level	Direct instrumental human elasticity measurement[13]	Supports skin elasticity and a firmer-looking appearance
Visible wrinkle/smoothness support	CoQ10	Moderate–strong	Human wrinkle observations plus UV/IL-6/MMP-1 mechanisms[14,15]	Supports smoother, younger-looking skin and visible age support
ECM homeostasis	Arjuna + CoQ10	Strong mechanistic rationale	Arjuna FGF-2/TGF-β/CTGF/TSP-1; CoQ10 collagenase and MMP-related evidence[13-15]	Supports pathways involved in maintaining dermal matrix homeostasis
Cellular bioenergetics	CoQ10	Strong mechanistic /translational	Epidermal replenishment and keratinocyte oxygen-consumption data[16]	Supports cutaneous cellular energy metabolism
Radiance / healthy appearance	Both	Indirect/moderate	Hydration, reduced scaliness, surface smoothness and oxidative support	Supports a healthier, more radiant-looking appearance

Abbreviations: CCT, caprylic/capric triglycerides; CoQ10, coenzyme Q10; ECM, extracellular matrix; FGF-2, fibroblast growth factor 2; MMP, matrix metalloproteinase; TEWL, transepidermal water loss; TGF-β, transforming growth factor β; TSP-1, thrombospondin 1; VEGF, vascular endothelial growth factor.

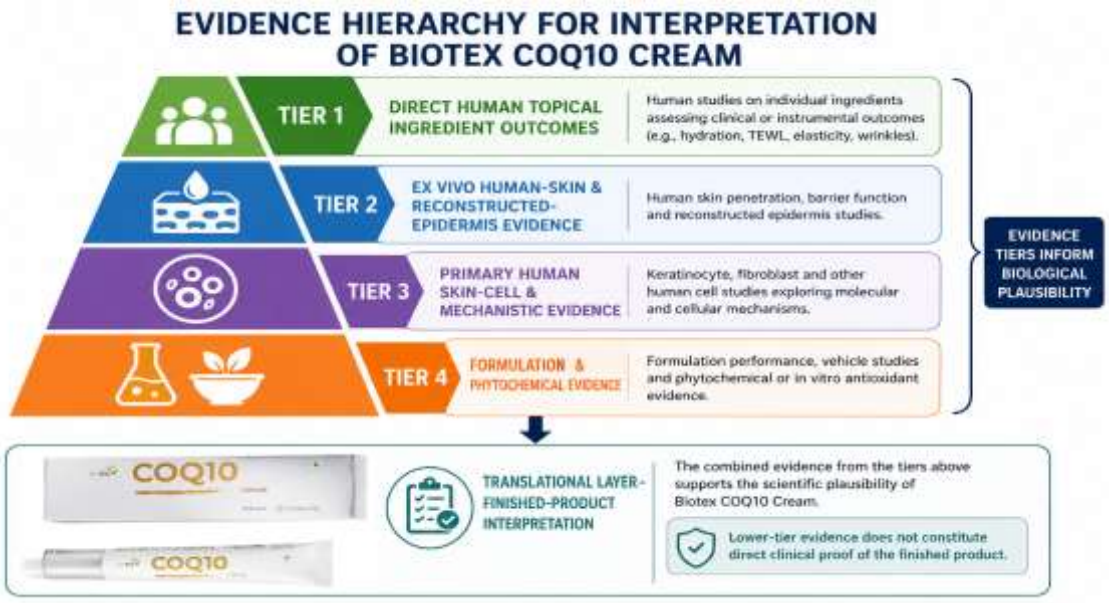

Fig 5: Evidence hierarchy for interpretation of Biotex COQ10 Cream. Direct human topical ingredient outcomes form the highest evidentiary tier, followed by ex vivo human-skin and reconstructed-epidermis evidence, primary human skin-cell and mechanistic evidence, and formulation or phytochemical evidence. Finished-product interpretation is treated as a separate translational layer because lower-tier evidence informs biological plausibility but does not constitute direct clinical proof of the combined Biotex formulation.

17. Safety and Topical Tolerability

The topical safety profile of a finished cream depends on the complete formulation, not merely on the active ingredients. Nevertheless, ingredient-level data can identify relevant expectations and boundaries. *T. arjuna* has a long history of traditional use, and modern bark reviews describe a generally favourable safety profile in available studies[19,20]. For topical use, Gaikwad and Jadhav ran a dermal irritation test on their emulsified system and observed no allergic dermal response; this was performed in albino rats, so it speaks to preclinical tolerability rather than to human skin compatibility[26]. Human tolerability of a different topical bark preparation is implicit in the vehicle-controlled clinical work by Farwick et al.[13], although that study was not designed as a formal safety trial.

CoQ10 is widely used in topical cosmetics and has generally shown favourable cutaneous tolerability in the published literature[14,16,27]. As with any topical ingredient, irritation can remain formulation-dependent, particularly when combined with surfactants, preservatives, fragrance or other excipients not addressed in this ingredient-focused review. CoQ10 should therefore be described as generally well tolerated rather than universally non-irritating.

CCT has extensive cosmetic use and was included in a comprehensive Expert Panel safety assessment of triglycerides that concluded the reviewed ingredients are safe under current cosmetic conditions of use[18]. Rare individual reactions remain possible; a case report of allergic contact dermatitis attributed to caprylic/capric triglyceride illustrates that uncommon sensitisation should not be considered impossible[34]. The appropriate conclusion is therefore broad cosmetic compatibility with recognition of rare idiosyncratic reactions.

18. Evidence Boundaries, Limitations and Translational Interpretation

The evidence base is favourable but heterogeneous. First, the strongest Arjuna study evaluated a specific bark triterpene preparation, and its extraction profile may not be identical to the Arjuna raw material used in Biotex COQ10 Cream. Botanical extracts can vary substantially in marker content and polyphenolic

composition; consequently, whole-extract equivalence should not be assumed without analytical characterisation[19-21].

Second, CoQ10 penetration and efficacy are formulation-dependent. Published research includes conventional creams, hydrophilic systems, microemulsions and lipid nanoparticle systems[14,16,17,28-30]. These studies establish that topical CoQ10 can be delivered to epidermal compartments and can influence oxidative and bioenergetic endpoints, but they do not demonstrate that all topical vehicles deliver CoQ10 to the same degree. The presence of CCT is pharmaceutically rational, but product-specific penetration should not be inferred from unrelated lipid delivery systems.

Third, molecular endpoints should not be converted directly into consumer claims. Increases in FGF-2, TGF-β, CTGF or VEGF after exposure to Arjuna triterpenes and reductions in IL-6/MMP-related signalling with CoQ10 explain biological plausibility; they are not proof that the finished cream changes these biomarkers in users. Similarly, evidence for antioxidant activity does not justify disease-prevention or sunscreen-equivalent claims.

Finally, no direct clinical study of the combined Biotex finished product was identified in the evidence set on which this review is based. The manuscript therefore evaluates an ingredient architecture rather than a clinically validated final formulation. A further consideration is source independence: several of the pivotal CoQ10 reports[14,16,27] and the principal Arjuna study[13] were generated by, or in collaboration with, the companies supplying the respective ingredients. This does not invalidate findings that rest on objective instrumental endpoints, but it is a reason to weigh them alongside independent work such as the *ex vivo* penetration study[17] rather than in isolation. Neither limitation is unique to this product; both are common translational boundaries in the cosmeceutical literature. The scientifically appropriate conclusion is that the formulation is supported by convergent ingredient-level evidence, with the strength of each proposed claim determined by the highest available evidence tier.

19. Discussion

The literature supports a coherent, multi-compartment rationale for combining *T. arjuna* bark extract with CoQ10 in topical skin care. Importantly, this rationale is stronger when the ingredients are assigned distinct roles rather than grouped under a generic “antioxidant” label. Arjuna bark extract has unusually relevant direct human topical evidence for a botanical active, including objective measurement of TEWL, moisturisation and elasticity, supported by reduced scaliness and additional age-associated skin parameters[13]. CoQ10, by contrast, is anchored in endogenous mitochondrial and redox biology and is supported by topical replenishment, *ex vivo* penetration, human skin-cell and clinical wrinkle-related observations[14-17].

The Arjuna evidence is particularly valuable because barrier and hydration claims are frequently inferred from ingredient chemistry rather than measured in humans. The vehicle-controlled reduction in TEWL and the improvement in moisturisation reported by Farwick et al. provide a direct bridge from botanical phytochemistry to a clinically relevant skin-biophysical endpoint[13]. The concurrent elasticity improvement broadens the interpretation from simple moisturisation to biomechanical skin quality. The accompanying growth-factor and matrix-signalling data offer an explanatory framework but are best used to support, not replace, the human outcomes.

CoQ10 contributes a different form of strength. Its endogenous role in mitochondrial respiration is well established, and its antioxidant function is biochemically integrated with that role[12]. Topical studies demonstrate that CoQ10 can reach viable epidermal layers and increase local ubiquinone/ubiquinol levels[14,16,17]. The observation that keratinocytes exposed to concentrations corresponding to those achieved in treated epidermis showed increased oxygen consumption provides an unusually direct bridge between delivery and cellular bioenergetics[16]. This makes “bioenergetic support” a defensible scientific descriptor, provided it is not converted into exaggerated claims of rejuvenation.

The UV-related evidence further strengthens the CoQ10 narrative. Photoageing involves ROS generation, cytokine signalling and MMP induction, leading to ECM degradation[5,6,35]. CoQ10 attenuated UVA-associated oxidative endpoints in keratinocytes and collagenase expression in fibroblasts[14], while Inui et al. linked CoQ10 to reduced UVB-induced IL-6 in keratinocytes and lower MMP-1 production in fibroblasts exposed to keratinocyte-conditioned medium[15]. The clinical wrinkle observations reported in these studies are consistent with, rather than disconnected from, the mechanistic pathway.

CCT should be positioned conservatively. Its value lies in formulation science: it is a widely used emollient and skin-conditioning triglyceride, compatible with lipophilic actives and supported by a large cosmetic safety database[18], with *in vivo* evidence that a 15% emulsion raises surface hydration and lowers TEWL[31]. While lipophilic vehicles can influence partitioning into skin[32,33], the literature does not allow a

direct statement that CCT specifically enhances CoQ10 delivery in this cream. Preserving this distinction strengthens the manuscript because it prevents formulation speculation from diluting otherwise robust evidence.

The resulting product-supportive framework is therefore one of complementary evidence convergence. Arjuna bark targets clinically measurable surface and biomechanical domains—barrier, hydration, scaliness and elasticity—while CoQ10 targets antioxidant, mitochondrial and photoageing-related domains. These routes converge on the visible characteristics that define healthy-looking ageing skin: maintained hydration, smoother microrelief, resilience, elasticity and reduced appearance of wrinkle-related damage. The formulation can consequently be discussed positively without overstating certainty: it is biologically coherent, supported by human topical ingredient evidence on both main active domains, and consistent with contemporary understanding of skin ageing.

20. Conclusion

Terminalia arjuna bark extract and CoQ10 provide complementary, evidence-supported approaches to topical skin-ageing biology. Arjuna bark extract is supported by direct human topical findings showing reduced TEWL, improved moisturisation, reduced scaliness and increased elasticity, together with reconstructed epidermis and human-cell evidence relevant to ECM-associated signalling. CoQ10 is supported by its established endogenous role in mitochondrial electron transport and antioxidant defence, by topical studies demonstrating epidermal replenishment and ubiquinol formation, and by mechanistic and clinical observations relevant to oxidative stress, IL-6/MMP-1 signalling and wrinkle appearance. Caprylic/capric triglycerides provide a rational emollient lipid environment for the lipophilic CoQ10 component and contribute measurably to surface hydration and barrier support, while remaining a formulation component rather than an independent anti-ageing active. Collectively, these data provide a strong ingredient-level scientific rationale for Biotex COQ10 Cream as a formulation intended to support antioxidant defence, epidermal barrier integrity, moisture retention, elasticity and a smoother, resilient, healthy-ageing skin appearance. The evidence should be interpreted as support for the formulation architecture and its cosmetic positioning, distinct from direct clinical proof of the finished product.

21. Declarations for Journal Submission

Author Contributions: All authors contributed to the conception and scope of the review, literature interpretation, critical revision of the manuscript, and approval of the final version.

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Conflict of Interest: The authors are affiliated with Biotex Life Solutions Pvt. Ltd., the developer of Biotex COQ10 Cream. This affiliation represents a potential conflict of interest and is disclosed for transparency.

Data Availability: No new datasets were generated or analysed for this narrative review. All evidence discussed is derived from the cited published literature.

Ethics Approval: Not applicable; no new human or animal participants were enrolled for this review.

AI-Assisted Writing Disclosure: Artificial-intelligence-assisted tools were used for language refinement, organisation of the retrieved literature and preparation of the schematic figures (Figures 2-5). No AI tool was used to generate or alter experimental data. Scientific interpretation, reference selection, verification of every cited source against the primary record, and final responsibility for the manuscript remain with the authors.

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