2026 Volume: 01 Issue: 08 ISSN 1671-2838 Page No: 01-10

Review Article

Pharmaceutical Care and Research

https://pcrjournal.com

Volume: 01
Issue: 07

DERMA-PEARL: A REVIEW OF BOTANICAL BURST-BEAD TECHNOLOGY FOR HYBRID COSMETIC TINT AND SKINCARE FORMULATIONS

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Article Received: 23 September 2026

Article Revised: 13 October 2026

Published on: 2 November 2026

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DOI: https://doi-doi.org/101555/ijpcr.4391

ABSTRACT

The growing interest in multifunctional cosmetics has encouraged the development of products that combine decorative colour with skin-conditioning ingredients. DERMA-PEARL is a proposed water-based hybrid cosmetic tint incorporating pomegranate peel (Punica granatum L.) extract, black carrot (Daucus carota subsp. sativus) extract, niacinamide, D-panthenol, sodium hyaluronate and a visible burst-bead system. Pomegranate peel contains hydrolysable tannins and other phenolic constituents, including punicalagin and ellagic-acid-related compounds, that have attracted attention for their antioxidant and skin-related potential. Black carrot is a source of anthocyanin pigments that may provide purple-to-red colour; however, pigment stability is affected by formulation pH, temperature, light and oxygen. Niacinamide, D-panthenol and sodium hyaluronate are established topical formulation ingredients with literature supporting skin-conditioning or hydration-related roles. The proposed bead system is intended to remain dispersed in the continuous tint phase and rupture during application. This narrative review examines the skin barrier, the rationale for hybrid makeup–skincare products, the scientific basis for the selected ingredients, burst-bead design considerations, formulation risks and essential quality and safety tests. A critical distinction is made between evidence relating to individual ingredients and evidence required for the finished product. At present, DERMA-PEARL should be regarded as a formulation concept rather than a validated cosmetic product. Experimental work is required to establish bead integrity and rupture, colour performance, physicochemical and microbiological stability, skin compatibility and any claimed skincare benefit.

KEYWORDS: Hybrid cosmetics; skin tint; pomegranate peel; Punica granatum; black carrot; anthocyanins; niacinamide; panthenol; sodium hyaluronate; burst beads; cosmetic formulation.

1. INTRODUCTION

The skin forms a dynamic interface between the body and its environment. In addition to limiting water loss, it contributes to defence against microorganisms, irritants and other external exposures. The stratum corneum, the outermost layer of the epidermis, is a major determinant of this barrier function. Its corneocytes, intercellular lipids and natural moisturising components work together to regulate permeability and maintain surface hydration [1,2].

Cosmetic products are used to cleanse, moisturise, condition and enhance the appearance of the skin. Traditional makeup products such as foundations, blushes and tints primarily deposit colour, whereas skincare products are generally designed to support cleansing, moisturisation or skin conditioning. Hybrid makeup–skincare products seek to combine selected properties of these product categories in a single formulation. Their practical value depends on whether the finished product can deliver acceptable colour, texture, stability and skin feel without compromising safety.

DERMA-PEARL is proposed as a water-based tint containing botanical ingredients and commonly used topical skincare ingredients, with visible pearl-like beads dispersed in the base. Pomegranate peel is included as the principal botanical extract of interest, while black carrot extract is proposed as a natural pigment source. Niacinamide, D-panthenol and sodium hyaluronate provide the skin-conditioning component. The beads are intended to rupture during application and release their contents. The concept is scientifically plausible as a formulation-development project, but its performance cannot be inferred from the properties of the individual ingredients.

The purpose of this review is to critically discuss the scientific rationale and formulation requirements of DERMA-PEARL, identify uncertainties that require experimental investigation, and outline a practical evaluation framework. The review does not claim that the proposed formulation has already demonstrated clinical efficacy, controlled release or superiority over conventional tints.

2. Review approach

This article is structured as a narrative review. It draws on selected peer-reviewed literature addressing skin-barrier biology, pomegranate phytochemistry and skin-related research, black-carrot anthocyanin stability, topical niacinamide, panthenol, hyaluronic acid and cosmetic microbiological quality. Recent publications were prioritised where available, while selected earlier publications and international standards were retained for foundational or technical context. The discussion is a narrative synthesis rather than a systematic review: no formal protocol, duplicate screening, risk-of-bias assessment or exhaustive database search is claimed. Before journal submission, the authors should update the search in PubMed, Scopus, Web of Science and relevant formulation databases, record the search dates and terms, and verify every bibliographic detail against the original publication.

3. Skin structure and relevance to topical formulations

The skin is commonly described in terms of the epidermis, dermis and subcutaneous tissue. The epidermis provides the principal outer barrier, while the dermis contains connective tissue, vessels, nerves and appendages. The subcutaneous compartment contains adipose and connective tissue. For topical cosmetic development, the stratum corneum is particularly important because it controls much of the interaction between an applied product and the skin surface [1,2].

The stratum corneum is not an inert coating. Its corneocytes are embedded in an organised lipid matrix, and its hydration state and surface chemistry influence flexibility, desquamation and barrier performance. Moisturisers may combine humectants, which bind water; emollients, which soften the surface; and occlusive agents, which reduce water loss. The effect of a topical ingredient depends on its physicochemical properties, concentration, vehicle, contact time and the condition of the skin barrier [2,3].

A tint formulation must therefore balance skin feel and pigment deposition with the physical requirements of a stable product. Ingredients that bind water or increase viscosity may improve the sensory profile but can also alter spreadability, drying time, pigment distribution and bead suspension. The intended application site should be defined at the outset because a cheek tint, lip tint and product intended for use near the eyes have different exposure and safety considerations.

4. Hybrid makeup–skincare formulations

Hybrid cosmetics are designed to combine colour cosmetics with ingredients commonly used in skincare. Tinted moisturisers and skin tints are familiar examples. Their potential advantages include convenience and fewer application steps. Nevertheless, the presence of a skincare ingredient does not establish that a makeup product delivers the same performance as a dedicated serum or moisturiser. Concentration, stability, release, contact time and the complete formulation all influence the outcome.

For DERMA-PEARL, the formulation challenge is multidimensional: the base must support uniform colour, acceptable viscosity, bead suspension, appropriate application and preservation. The botanical extracts may contribute colour, odour, solids or pH shifts. The skincare ingredients may affect viscosity and compatibility. Accordingly, the complete formulation—not merely the ingredient list—must be evaluated.

5. Scientific basis of the proposed ingredients

5.1 Pomegranate peel extract

Pomegranate (Punica granatum L.) peel is a by-product of fruit processing and contains a range of phenolic constituents, including hydrolysable tannins, ellagitannins, punicalagin-related compounds, punicalin, ellagic acid, phenolic acids and flavonoids. The composition depends on cultivar, growing conditions, maturity, processing, drying and extraction conditions. Recent reviews describe extraction

and purification approaches for pomegranate-peel polyphenols and discuss their potential applications [4,5].

A 2024 review specifically examined pomegranate extracts in relation to healthy and diseased skin, summarising preclinical and other skin-related evidence [5]. A 2025 review further discussed extraction and purification of peel polyphenols, with emphasis on punicalagin [4]. These publications provide a rationale for investigating pomegranate peel as a cosmetic botanical; they do not prove that an uncharacterised peel extract will exert a measurable effect in DERMA-PEARL.

For formulation development, the extract should be characterised using a reproducible extraction procedure and, where feasible, a suitable marker-based method such as total phenolic content and chromatographic profiling. Batch-to-batch variation should be controlled. The extract may influence colour, odour, pH, solubility and physical stability. Its concentration should be selected through compatibility and tolerability studies rather than by assuming that a higher extract level is necessarily better.

5.2 Black carrot extract as a natural colourant

Black carrot (Daucus carota subsp. sativus) is a source of anthocyanin pigments that can produce purple, violet and red-purple hues. Anthocyanins are structurally sensitive compounds; their colour and stability can be affected by pH, temperature, light, oxygen and interactions with other formulation components. A 2024 review of anthocyanin stability describes these environmental influences and approaches to improving pigment stability [6].

A 2025 review focused specifically on black-carrot anthocyanins and discusses stabilisation approaches including encapsulation, copigmentation and acylation [7]. Experimental work published in 2024 also examined the light stability of individual black-carrot anthocyanins and the influence of acylation [8]. Although much of this evidence arises from food systems, it identifies relevant degradation variables that should be assessed in a cosmetic vehicle. Direct extrapolation from food matrices to topical cosmetics is not justified.

For DERMA-PEARL, the black-carrot extract should be evaluated for shade, colour strength, uniformity, pH sensitivity and storage stability in the actual base. Colour should be measured instrumentally where possible (for example, CIELAB coordinates and colour difference, ΔE), alongside visual assessment under standardised lighting. Compatibility with pomegranate peel extract and bead contents must also be examined.

5.3 Niacinamide

Niacinamide (nicotinamide; vitamin B3) is widely used in topical cosmetic formulations. A 2024 review examined dermal delivery strategies and clinical evidence for topical niacinamide, including its relevance to skin-barrier function and skin appearance [9]. Its performance in a particular formulation will depend on concentration, vehicle, pH, stability and exposure conditions.

In DERMA-PEARL, niacinamide is proposed as a skin-conditioning ingredient. Its inclusion should not be used to make therapeutic claims. Formulation studies should assess its compatibility with the

aqueous base, botanical extracts and preservation system, and should confirm that the selected pH and storage conditions are appropriate.

5.4 D-panthenol

D-panthenol (dexpanthenol) is a provitamin form of pantothenic acid used in topical products for skin-conditioning and moisturising purposes. A review of the evidence for dexpanthenol in dermatological care discusses its use in formulations intended to support hydration and barrier-related outcomes [10]. The evidence for a given product depends on the finished vehicle, concentration and intended use.

In a hybrid tint, D-panthenol may contribute to the skin-conditioning profile, but it may also influence the sensory properties of the aqueous phase. Its concentration should be optimised with respect to viscosity, tackiness, drying time and compatibility with the pigment and bead system.

5.5 Sodium hyaluronate

Sodium hyaluronate is the sodium salt of hyaluronic acid and is used in topical formulations because of its water-binding and rheological properties. A literature review and clinical evidence synthesis discussed topical hyaluronic acid in relation to skin quality and signs of ageing [11]. A 2024 randomised controlled study compared topical hyaluronic acid preparations with different molecular weights in xerosis [12].

The grade and molecular characteristics of sodium hyaluronate may affect viscosity, film formation and sensory feel. In DERMA-PEARL, excessive viscosity could hinder spreading or alter the suspension and movement of beads. The ingredient should therefore be evaluated at more than one concentration, with attention to rheology and application performance.

6. Burst-bead technology and proposed product architecture

Encapsulation and particulate delivery approaches are used in personal-care formulations to separate ingredients, protect sensitive materials or influence their release. The performance of a bead system depends on its wall material, core composition, size distribution, mechanical strength, manufacturing process and compatibility with the surrounding vehicle. The term “burst bead” should be used as a design description until rupture and release have been experimentally demonstrated.

The proposed DERMA-PEARL architecture contains a continuous water-based tint phase and visible beads dispersed throughout it. The formulation design must define whether the beads contain black-carrot pigment, pomegranate extract, skincare ingredients or a combination. If the beads contain pigment, rupture may contribute to colour release. If skincare ingredients are dissolved in the continuous phase, they are already present at the skin interface and bead rupture may not meaningfully control their delivery.

A successful system would need to remain physically intact during mixing, filling, transport and storage, yet rupture under the mechanical stress generated during application. These requirements may conflict. Beads that are too fragile may break during manufacture or storage; beads that are too

strong may not rupture during use. The base must be viscous enough to limit sedimentation or creaming but fluid enough to spread comfortably.

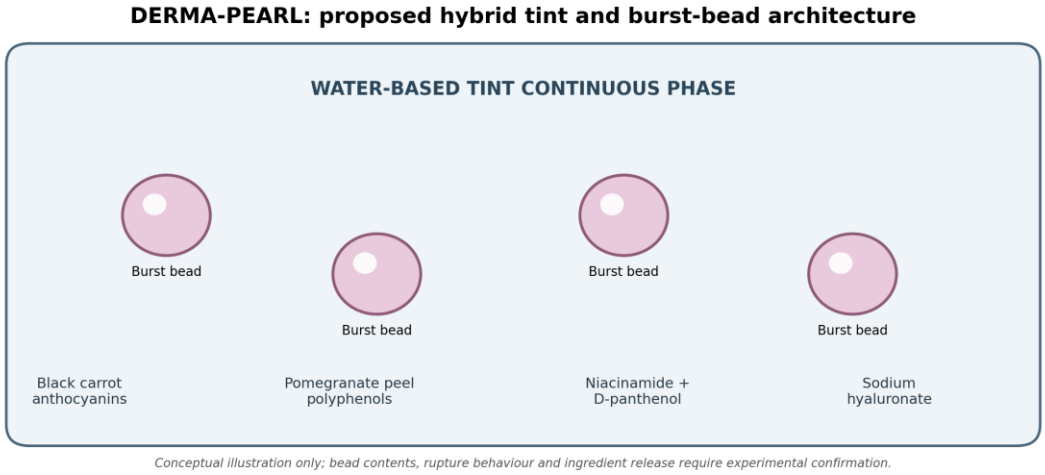


Figure 1. Conceptual architecture of DERMA-PEARL showing a continuous tint phase and dispersed burst beads. The drawing is a proposed design schematic, not evidence of a tested formulation or confirmed release mechanism.

7. Proposed formulation considerations

The final composition cannot be responsibly fixed from the current concept alone because the bead core and shell materials, target shade, intended application site, preservative system and manufacturing process have not yet been specified. A staged formulation-development strategy is therefore preferable to assigning arbitrary ingredient percentages.

Component	Proposed role	Key development questions
Aqueous tint base	Continuous phase; spreadability and product structure	What is the target viscosity and pH? Is the base compatible with all actives and the preservative?
Pomegranate peel extract	Botanical polyphenol source	How is it standardised? Does it alter odour, colour, pH or microbial burden?
Black carrot extract	Anthocyanin-based colour source	What shade and colour strength are achieved? How stable is the pigment under light and storage?
Niacinamide	Skin-conditioning ingredient	Is the selected pH and concentration compatible with the other components?
D-panthenol	Skin-conditioning/humectant component	Does it cause tackiness or alter drying and spreadability?
Sodium hyaluronate	Water binding and rheology modification	Does it increase viscosity excessively or affect bead suspension and release?
Burst beads	Visual feature and proposed rupture/release unit	What are the shell/core materials, size distribution, rupture force and release profile?
Preservative system	Microbial protection of water-containing product	Is the system compatible with botanical extracts and validated by an appropriate preservation efficacy test?
Packaging	Protection during storage and dispensing	Does packaging protect against light, oxygen, contamination and bead damage?

8. Quality evaluation and safety assessment

The evaluation programme should be designed around the risks of the complete formulation. A water-based cosmetic containing botanical materials requires attention to microbial quality and preservation. ISO 11930 describes approaches for evaluating the antimicrobial protection of cosmetic products, including a preservation efficacy test and an overall protection assessment [13]. ISO 17516 provides microbiological limits for cosmetics and remains a relevant reference standard, subject to checking its current revision status before submission or laboratory use [14].

Test / attribute	Suggested evaluation	Reason for inclusion
Appearance and homogeneity	Visual examination; document separation, clumping, precipitation and bead distribution	Detects gross physical instability
pH	Calibrated pH meter at defined temperature and time points	Relevant to ingredient compatibility, pigment behaviour and skin tolerability
Viscosity / rheology	Brookfield or suitable rotational rheometer; specify spindle, speed and temperature	Assesses spreadability and bead suspension
Spreadability and sensory properties	Standardised spread test plus structured user-panel assessment after ethics/safety review	Assesses application performance and skin feel
Colour performance	CIELAB colour measurement, ΔE, shade uniformity and rub-out assessment	Measures pigment consistency and colour drift
Bead size and integrity	Microscopy/image analysis; quantify intact beads before and after storage	Assesses size distribution and physical integrity
Rupture and release	Standardised mechanical application test; quantify rupture fraction and released marker/pigment	Tests the defining burst-bead claim
Centrifugation / stress testing	Defined centrifugation and temperature cycling as screening tests	Identifies early signs of instability; does not replace real-time stability
Stability	Real-time and justified accelerated studies in final packaging; monitor pH, viscosity, colour, odour and beads	Supports shelf-life assessment
Microbial quality	Microbial limits testing and preservative efficacy/challenge testing as applicable	Controls contamination risk in the water-based product
Skin compatibility	Appropriate irritation/sensitisation assessment and, if justified, controlled human compatibility study	Supports safe use for the intended application site

9. Critical discussion and research gap

The literature provides a rationale for investigating the selected ingredients, but it does not establish the performance of DERMA-PEARL as a combined product. Evidence for pomegranate peel is dependent on extract composition and study model; evidence for black-carrot anthocyanins largely highlights pigment stability challenges and stabilisation strategies. Topical niacinamide, panthenol and hyaluronic acid have their own bodies of literature, but their individual evidence cannot be transferred directly to a tint containing multiple botanicals, pigments and beads.

The principal research gap is the lack of product-specific evidence on the compatibility and performance of the proposed combination. In particular, it is not yet known whether pomegranate peel

extract and black-carrot anthocyanins remain stable together in the selected aqueous vehicle; whether the beads can survive processing and storage while rupturing reproducibly during application; whether bead rupture produces a measurable functional advantage; or whether the finished product maintains acceptable microbial quality and skin compatibility.

A meaningful experimental comparison should include at least a conventional tint base without beads and the complete bead-containing formulation. Where feasible, additional controls should separate the effects of botanical extracts and skincare ingredients. This design would help determine whether the beads provide a measurable advantage rather than merely a visual novelty. Claims such as “controlled release”, “enhanced antioxidant protection”, “anti-ageing”, “barrier repair” or “superior hydration” should be withheld unless supported by appropriate tests on the finished product.

The natural origin of an ingredient is not evidence of safety. Botanical extracts may contain variable constituents, residual solvents or contaminants, and may cause irritation or sensitisation. Ingredient quality, impurity control, microbiological quality, preservative efficacy, packaging compatibility and intended-use exposure must be considered during development.

10. Suggested experimental development pathway

Stage	Work package	Decision / output
I.Raw-material qualification	Authenticate botanical sources; define extraction procedures; record yield; establish marker/phenolic and pigment profiles	Reproducible raw materials with defined specifications
II. Preformulation	Screen pH, solubility, colour, odour, ingredient compatibility and preliminary viscosity	Select compatible ingredient grades and a feasible base
III.Bead development	Select shell/core materials; optimise bead size, mechanical strength and loading; assess mixing/filling tolerance	Beads remain intact in product and rupture under defined application stress
IV.Prototype Optimisation	Prepare trial batches; optimise base rheology, bead loading and pigment level	Uniform, spreadable prototypes with acceptable appearance
V. Product evaluation	Conduct physicochemical, colour, bead, microbial and stability testing	Evidence-based prototype selection
VI. Safety and claims substantiation	Assess safety for intended application site; test only claims that can be supported	Defined intended use and defensible cosmetic claims

11. CONCLUSION

DERMA-PEARL represents a proposed hybrid cosmetic tint concept that combines pomegranate peel extract, black-carrot anthocyanins, niacinamide, D-panthenol, sodium hyaluronate and a visible burst-bead system. The scientific literature supports investigation of these ingredients for their respective phytochemical, pigment and skin-conditioning roles. However, ingredient-level evidence does not establish the efficacy, stability or safety of the combined formulation.

The feasibility of DERMA-PEARL will depend on standardised botanical raw materials, pigment stability, compatibility of the aqueous base, appropriate rheology, bead integrity and reproducible rupture, effective preservation, packaging and safety assessment. Comparative testing against a

conventional tint without beads is particularly important to establish whether the proposed bead technology provides a practical benefit. Until these studies are completed, DERMA-PEARL should be described as a formulation concept under development, and no specific therapeutic or superior skincare claim should be made.

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