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A REVIEW ON STEM CELL DERIVED INGREDIENTS IN COSMETIC FORMULATIONS

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ABSTRACT

Stem-cell-derived compounds represent a rapidly evolving category in cosmetic science due to their regenerative and bioactive potential. These ingredients support cellular renewal by aiding in the replacement of damaged skin cells and promoting tissue restoration. Cosmetic formulations commonly utilize extracts from plant stem cells (e.g., apple, grape, lotus) and human stem cell–conditioned media obtained from sources such as adipose tissue or dental pulp. Their activity stems from the presence of antioxidants, growth factors, polyphenols, peptides, cytokines, and fatty acids, which contribute to skin rejuvenation, hydration, wound healing, and anti-aging effects. Current research focuses on protecting native skin stem cells to delay aging by enhancing their resilience against oxidative stress and cellular deterioration. Plant biotechnology allows for consistent and sustainable synthesis of active compounds, while human stem cell–conditioned media provide advanced regenerative substances such as cytokines and exosomes. This review discusses the origin, mechanisms, efficacy, formulation techniques, regulatory aspects, and future prospects of stem-cell-derived materials in topical cosmetic applications. The study further highlights the need for innovation and sustainability in developing safe and high-performing cosmeceutical products.

Keywords: Stem cells, cosmetics, cytokines, growth factors, plant stem cell extracts, conditioned media, cosmeceuticals.

INTRODUCTION

Stem-cell-based ingredients have gained significant interest in cosmetic biotechnology due to their regenerative capacity and cellular signaling properties. Cosmetic products incorporating such biomaterials are frequently formulated using either plant stem cell culture extracts, rich in phytochemicals and antioxidants, or human stem cell–conditioned media, which contain growth-enhancing and restorative elements such as

cytokines, extracellular vesicles, and growth factors. Stem cells are undifferentiated biological units capable of self-renewal and differentiation into specialized cell types. Unlike most somatic cells, which possess limited proliferative ability, stem cells are instrumental in tissue maintenance and regeneration. The use of stem cell biotechnology ensures higher consistency and purity of cosmetic ingredients compared to conventional botanical extracts, which often struggle with variability and contamination. . Stem cells possess the unique ability to self-renew and differentiate into various cell types, making them highly valuable in tissue regeneration and skin rejuvenation therapies. In cosmetic science, both plant and human stem cell–derived extracts are incorporated to support cellular repair, enhance skin barrier function, and improve overall skin vitality. These extracts are rich in growth factors, cytokines, antioxidants, and signaling molecules that stimulate collagen synthesis, increase elastin production, and support wound healing. Exposure to environmental stressors such as ultraviolet radiation, pollution, and oxidative agents accelerates premature aging, leading to wrinkles, hyperpigmentation, and loss of skin elasticity. Conventional anti-aging treatments often provide limited results due to superficial action.

In contrast, stem cell–based ingredients penetrate deeper skin layers and modulate cellular mechanisms responsible for regeneration, thereby offering more effective long-term benefits. Conditioned media from human mesenchymal stem cells (MSCs) and extracts from plant stem cells are increasingly integrated into topical formulations, including serums, creams, and wound-healing agents. These components not only support dermal matrix restoration but also exhibit anti-inflammatory, antioxidant, and protective properties. Technological advancements in stem cell culture, callus induction, and bioreactor systems have facilitated large-scale production of biologically active compounds for cosmetic applications. Research findings indicate that stem cell–derived ingredients can promote epidermal renewal, accelerate tissue repair, and reduce signs of ageing without the ethical or biological complications associated with direct stem cell transplantation. Therefore, the incorporation of stem cell–derived materials into cosmetic formulations represents a promising strategy for improving skin health, combating aging, and enhancing post-injury recovery. With increasing consumer demand for effective aesthetic enhancement, the global cosmetic industry is expanding rapidly. The global market was projected to reach USD 500 billion by 2020, growing approximately 3.5–4.5% in five years. In India, the cosmetic sector is estimated to have risen from INR 60 billion to INR 170 billion, exhibiting growth rates of 15–20% annually. The term “stem cell” was first introduced by Ernst Haeckel, a German biologist, in 1868. Over time, advancements in stem cell research have transitioned from medical applications into modern cosmetic innovation.

ANTIOXIDANT AND ANTI-AGING POTENTIAL OF STEM CELL EXTRACTS

Scientific studies indicate that kinetin—a cytokinin found in high quantities in the stem cells of fruits such as raspberries and citrus—plays a crucial role in slowing cellular aging. Kinetin exhibits strong antioxidant properties and safeguards cellular

components including nucleic acids and proteins from oxidative degradation. It performs this function by:

- Stimulating superoxide dismutase via copper ion interaction,
- Activating restorative enzymes responsible for DNA repair,
- Inhibiting the formation of 8-oxo-dG, a biomarker of oxidative damage.

Additionally, kinetin supports epidermal regeneration by enhancing keratinocyte production, improving skin barrier function, and reducing trans-epidermal water loss. This contributes to improved skin stem cell vitality and delayed aging signs. Evidence suggests that extracts derived from *Rhus coriaria* possess strong antioxidant and anti-aging activities, primarily due to their high concentration of phenolic compounds, particularly gallic acid. Studies have shown that topical application of these extracts accelerates wound healing by supporting tissue regeneration at the microscopic level. Additionally, such extracts maintain structural integrity by enhancing collagen synthesis and limiting oxidative damage. Excessive sun exposure leads to premature skin aging through increased free radical production, which disrupts cellular processes and collagen formation. Oxidative stress impairs mitochondrial respiration, obstructing metabolic activity and delaying the healing process. Bioactive ingredients in stem cell extracts enable tissue protection by neutralizing reactive oxygen species and reducing damage caused by ultraviolet radiation. Conditioning mediums derived from plant-based or mesenchymal stem cells contain various cytokines and growth factors that regulate inflammatory responses and support neovascularization, leading to improvement in skin architecture. When applied in cosmetic formulations, these compounds stimulate fibroblast proliferation, elevate elastin and hyaluronic acid production, and improve moisture retention, resulting in smoother, firmer skin. Additionally, they support removal of dead and damaged cells, aiding in tissue restructuring. Some growth factors are capable of reducing excessive melanin synthesis by inhibiting tyrosinase enzyme activity, contributing to skin tone enhancement and brightening effects. Overall, continuous application of stem cell-based extracts may diminish wrinkle formation, enhance elasticity, and offer protective effects against age-related cellular deterioration.

ROLE OF STEM CELLS IN SKIN REGENERATION AND WOUND HEALING

Research on plant extracts, such as those from *Rhus coriaria*, has shown significant improvement in skin repair processes due to the presence of gallic acid, myricetin, quercetin, and tannins. In experimental wound models, hydrogels infused with *R. coriaria* extracts enhanced healing through increased nitric oxide and hydroxyproline production. Stem cells are widely recognized in regenerative medicine for treating conditions with limited therapeutic options. When applied to tissue, stem cells can differentiate and form specialized cells. However, their efficacy depends on growth factors and cytokines necessary for survival and integration. It has been observed that these bioactive substances are present in stem-cell-conditioned media and can independently promote tissue regeneration. Such media are increasingly applied in cosmetic formulations targeting skin rejuvenation, hair restoration, and under-eye

treatments. Growth factors and cytokines present in the conditioned medium stimulate collagen and elastin synthesis, contributing to improved skin elasticity and reduced wrinkling. Macrophage activation leads to cellular debris removal, while fibroblast stimulation assists in tissue repair. Certain biomolecules also regulate melanin production, resulting in skin brightening and reduction of hyperpigmentation.

Stem cells are increasingly recognized in regenerative medicine for their potential to manage complex medical conditions due to their ability to differentiate into specialized cell types when introduced into damaged tissues. Their therapeutic effectiveness, however, largely depends on the presence of supportive molecules such as growth factors and cytokines. Research indicates that these signaling molecules are naturally secreted into the conditioning medium during stem cell culture, enabling their utilization without transplanting whole cells. This conditioned medium is rich in biologically active components that can be applied in the formulation of skincare, hair care, and treatments targeting dark circles in both inflamed and non-inflamed conditions. It is suggested that regulation of inflammatory responses may be linked to enhanced activity of matrix metalloproteinase 8 and myeloperoxidase. In an in vivo evaluation, application of a hydrogel containing ethanol-based extract from *R. coriaria* accelerated healing through increased synthesis of hydroxyproline and nitric oxide. Cytokines and growth factors present in the conditioned medium support cell proliferation and promote collagen, elastin, and hyaluronic acid production, which contribute to skin firmness and elasticity. By stimulating fibroblasts and macrophages, these molecules assist in tissue reconstruction and removal of damaged cells. Additionally, certain cytokines inhibit melanin formation, leading to improved skin tone, while epidermal thickening caused by human stem cell-derived growth factors contributes to anti-aging and skin tightening effects.

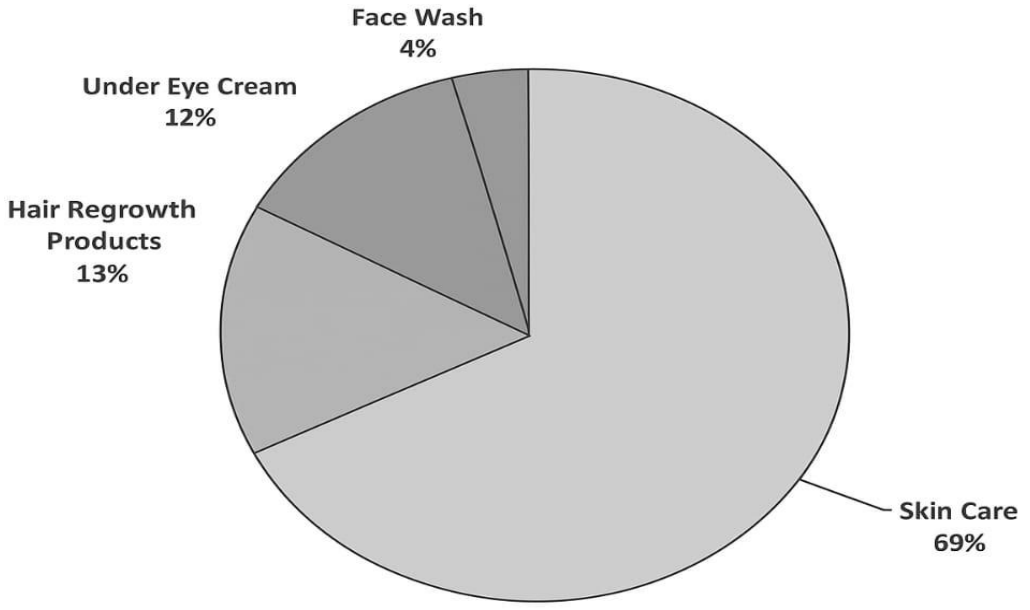

Fig: 1 Segment wise analysis of internationally marketed conditioned media based cosmetic products.

Plant stem cell-derived ingredients:

CULTURING:

In this process, firstly collecting and sterilizing a plant source. Like Murashige and Skoog (MS) medium — these are specialized mediums. It induces the callus formation and subculturing.

OPTIMIZATION:

The cell line with the highest biomass production can be chosen for large-scale production.

EXTRACTION:

By using high-pressure homogenization after achieving a suspension culture, lyse the cells and release the active ingredients.

FORMULATION:

The resulting extract is encapsulated in carrier systems to improve its stability and topical delivery into the skin.

Step	Description	Outcome/Ingredient
1. Source Selection	Selection of a plant (e.g., Apple, Grape, Ginger) known for beneficial compounds.	Plant Explant (tissue)
2. Callus Induction	A small piece of plant tissue is cultured in a sterile medium (like Murashige and Skoog) with hormones (auxins, cytokinins).	Undifferentiated Callus (Plant Stem Cell Mass)
3. Cell Culture	Callus/cells are grown in a bioreactor under controlled conditions (temperature, nutrients) for proliferation and compound synthesis.	High Biomass / Cell Suspension
4. Extraction & Purification	Physiologically active compounds are released into the medium or extracted from the cells, followed by purification and concentration.	Plant Stem Cell Extract (Rich in antioxidants, peptides, growth factors, etc.)
5. Formulation	The purified extract is incorporated into cosmetic products (creams, serums, etc.).	Cosmetic Product (Anti-aging, antioxidant, skin barrier repair)

Human or animal stem cell-derived ingredients:

CULTURING:

Stem cells (e.g., adipose-derived mesenchymal stem cells (ADMSCs)) are grown in conditioned medium.

COLLECTION: Growth factors, cytokines and extracellular vesicles (EVs) that are secreted into the conditioned medium are collected.

PROCESSING: The medium is processed to isolate specific components like the secretome or exosomes.

FORMULATION: The isolated components are then formulated into topical products like creams or serums or used in more advanced applications.

Step	Description	Outcome/Ingredient
1. Source Selection	Obtaining human or animal-derived Mesenchymal Stem Cells (MSCs) from ethically approved sources (e.g., bone marrow, adipose tissue, umbilical cord).	Isolated Mesenchymal Stem Cells (MSCs)
2. Cell Culture	MSCs are cultured in a specialized growth medium, where they secrete various beneficial signaling molecules.	Conditioned Medium (CM)
3. Collection & Concentration	The medium (CM) is collected, filtered to remove cells, and concentrated to isolate the secreted factors.	CM Concentrate (Rich in growth factors, cytokines, and exosomes)
4. Formulation	The concentrated CM is incorporated into cosmetic products. Note: The product does not contain the stem cells themselves, only the secreted factors.	Cosmetic Product (Focus on cell communication, rejuvenation, wound healing)

OBJECTIVES

1. To analyze the cellular communication mechanisms involving growth factors, cytokines, and exosomes in skin repair and aging modulation.
2. To compare phytochemical-rich plant stem cell extracts with human stem cell–conditioned media in terms of composition and functionality.
3. To evaluate scientific and clinical evidence regarding cosmetic impact on wrinkles, pigmentation, hydration, and wound healing.
4. To examine formulation strategies including encapsulation and stabilization techniques.
5. To review regulatory, ethical, and safety considerations due to the absence of standardized guidelines.
6. To explore future trends such as secretome-based actives and sustainable production technologies in next-generation cosmetic innovations.

   Analysis of recent literature (2015–2025) demonstrates increasing use of plant-based stem cell extracts, human adipose-derived stem cell conditioned media, and

engineered stem-cell metabolites in advanced cosmetic formulations. Most studies reported enhanced collagen production, improved hydration levels, increased antioxidant resistance, and accelerated wound healing. The use of encapsulation systems, such as liposomes or nanocarriers, was shown to improve stability and skin penetration. However, the variability in regulation and safety testing remains a concern, especially for human-derived materials.

CONCLUSION

Stem cell–derived bioactive compounds have gained substantial popularity in the cosmetic industry due to their ability to support skin regeneration, repair, and anti-aging mechanisms. Extracts obtained from both plant and human stem cells contain valuable compounds such as polyphenols, peptides, fatty acids, cytokines, and growth factors that contribute to overall skin health. Although promising, their use requires careful consideration of formulation safety, standardization, regulatory compliance, and ethical sourcing. Continued research and innovation are crucial for developing reliable and sustainable stem cell–based cosmeceuticals capable of meeting the rising expectations of modern consumers.

REFERENCE

1. Bhoir, T.; Jadhav, S.; Khatri, N. Biotech beauty: A novel perspective in cosmetics. Int. J. Adv. Pharm. Med. Bioallied Sci. 2022, 10, 49–58.
2. Cho, W.K.; Kim, S.-Y.; Seo, J.; Shin, D.S.; Jo, Y.; Choi, J.; et al. Anti-aging effects of *Leontopodium alpinum* (Edelweiss) callus culture extract through transcriptome profiling. Genes 2020, 11, 230.
3. Miastkowska, M.; Sikora, E. Anti-aging properties of plant stem cell extracts. Cosmetics 2018, 5, 55.
4. Bapat, V.A.; Kavikishor, P.B.; Jalaja, N.; Jaina, S.M.; Penna, C. Plant cell cultures: Biofactories for the production of bioactive compounds. Agronomy 2023, 13, 858.
5. Bouzroud, S.; El Maaiden, E.; Sabeh, M.; Mezghoub, N.; Boukcim, H.; Ousini, L.; El Kharras, Y. Biotechnological approaches to producing natural antioxidants: Anti-ageing and skin longevity prospects. Int. J. Mol. Sci. 2023, 24, 1397.
6. Georgiev, V.; Slavov, A.; Vasileva, I.; Pavlov, A. Plant cell culture as emerging technology for production of active cosmetic ingredients. Eng. Life Sci. 2018, 18, 779–798.
7. Yichit, W.; Saewan, N.; Poinyayou, T. Anti-aging efficacy of Thai red rice callus cosmetic product. J. Appl. Sci. 2018, 17, 63–72.
8. Bhoir S, Jadhav S, Khatri N. Biotech beauty: A novel perspective in cosmetics. Int J Adv Pharm Med Bioallied Sci. 2022;10:49–58.
9. Hang YK, An S, Lee YH, et al. Potential anti-ageing effects of probiotic-derived conditioned media on human skin cells. Acta Pharm. 2022;72(3):359–374.
10. Wang X, Wang Q, Xin P, et al. Secretome of human umbilical cord mesenchymal stem cell maintains skin homeostasis by regulating multiple skin physiological functions. Cell Tissue Res. 2023; 391(1): 111–125.

11. Kim HJ, Jung MG, Huo YK, Jung AH. A study on clinical effectivenes of cosmetics containing human stem cell-conditioned media. Biomed Dermatol. 2020;4(1).
12. Bhat S. Human mesenchymal-stromal cells-derived conditioned-medium-based formulation for advanced skin care. J Stem Cells Res Dev Ther. 2019;5:1–8.
13. Chen S, He Z, Xu J. Application of adipose-derived stem cells in photoaging: Basic science and literature review. Stem Cells Res Ther. 2020;11(1):491.
14. Muthu S, Bapat A, Jain R, Jeyaraman N, Jayasaman M. Exosomal therapy– a new frontier in regenerative medicine. Stem Cell Investig. 2021;8.
15. Devidasrao Ramdasi R, Ramdasi S. Growth factors and cytokines secreted in conditioned media by mesenchymal stem cells – promising possible therapeutic approach for hair regeneration. 2016, Vol. 6.
16. Bambulova A, Appone F, Colluci G. Plant cell cultures as source of cosmetic active ingredients. Cosmetics. 2014;1:94–104.
17. Cappuzzello C, Doni A, Dander E, Pasqualini F, Nebuloni M, Bottazzi B, Mantovani A, Biondi A. Mesenchymal stromal cell-derived PTX3 promotes wound healing via fibrin remodelling. J Invest Dermatol. 2016;136:293–300.
18. Nunes AM, Lily S, Sun C, Kinnunen TK, Fesrog DG. Fibroblast growth factors as tissue repair and regeneration therapeutics. PeerJ. 2016;4:e1533.