Glycerol: An unsung moisturising skin hero

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ABSTRACT

There are not many compounds that are of such great importance to the skin, yet actually receive so little attention as glycerol. It is a natural component of our body and vital for the normal functioning of our largest organ, the skin. It is therefore not surprising that glycerol is also one of the key ingredients in cosmetics (being the second most frequently used ingredient after water) mostly due to its moisturising effect. Let's get to know it a little bit better.

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BRIEF INTRODUCTION

There are not many compounds that are of such great importance to the skin, yet actually receive so little attention as glycerol. It is a natural component of our body and vital for the normal functioning of our largest organ, the skin. It is therefore not surprising that glycerol is also one of the key ingredients in cosmetics (being the second most frequently used ingredient after water), mostly due to its moisturising effect. Let's get to know it a little bit better.

WHAT IS GLYCEROL AND WHERE CAN WE FIND IT?

Glycerol or glycerin (chemically known as propane-1,2,3-triol and by the formula $C_3H_8O_3$) is a clear, colourless, viscous liquid with a sweet taste. It is **water soluble and hygroscopic**, which means that it attracts and holds water molecules from its surroundings (1). It is able to retain its own weight in water in just three days (2)!

It is used in various sectors: in the food industry (as a sweetener, thickening agent and preservative), in the manufacturing of anti-freezing liquids, in medicine as a laxative, in cough syrups and dermatological preparations, in cosmetics as a starting material in the manufacturing of cosmetic ingredients and even in the production of explosives (2).

Glycerol has a long history of use and an **excellent safety profile**. It is considered non-toxic, non-irritating and non-allergenic, and is classified by the U.S. Food and Drug Administration (FDA) as a generally recognised as safe (GRAS) substance. Glycerol obtained from natural sources is included on the list of exemptions of REACH (the European Union regulation governing the protection of human health and the environment from the chemical risks), Annex V (3–5).

It is a **naturally occurring substance**, but is rarely present in nature in its free form. It is found bound in the triglycerides of vegetable and animal oils and fats. A great majority of commercially available glycerol used worldwide is produced by splitting these oils and fats. However, it can also be produced synthetically (6).

Finally, in terms of skin-related facts, it is of the greatest interest for us that glycerol is physiologically produced and also exhibits effects in our skin. It is derived from triglycerides in sebaceous glands and transported through aquaporin channels, which are proteins responsible primarily for epidermal water transport. Glycerol functions mostly as a **moisturiser**, which correlates well with findings that the upper layer of the skin is more hydrated in sebaceous gland-enriched sites, such as the forehead or upper back (2).

GLYCEROL'S NO. 1 EFFECT: SKIN MOISTURISATION

The outermost layer of the skin (more precisely, of the epidermis) is the stratum corneum, which is composed mostly of corneocytes and an extracellular lipid matrix. It functions as a barrier between the body and the environment, and is responsible for preventing excessive water evaporation from the epidermis. If this function fails and there is a low water content in the stratum corneum, our skin becomes dry, scaly and flaky, all of which can result in pain and itchiness.

Maintaining optimal stratum corneum hydration is of the utmost importance for normal skin physiology, as water serves the function of a plasticiser in the stratum corneum, improving softness and flexibility. In addition, it is indispensable for the normal functioning of stratum corneum enzymes. A very important role in keeping our skin moisturised is played by highly hygroscopic compounds both within and between the corneocytes, and one of these is glycerol (2).

Knowing this, it is no surprise that glycerol cannot be overlooked when checking the ingredient list on bottles of moisturisers. So, what is glycerol's true place in the flooded repertoire of moisturising compounds?

Moisturising agents are divided into three main types depending on their mechanism of action (7, 8). **Humectants** are hygroscopic substances that attract water into the outer layer of the skin from both the environment and from deeper skin levels. Glycerol is one of the most effective humectants, and the other well-known examples are hyaluronic acid, urea, propylene glycol and its natural alternative propanediol, and panthenol. Humectants are also important from a technological aspect, as they prevent water evaporation from a cosmetic product and prevent thickening. The second group, **emollients**, supply the epidermis with the skin's own or similar lipids, for example vegetable butters and oils or synthetic triglycerides, squalene, cholesterol and phytosterols. These compounds have also been shown to affect skin barrier function, cell signalling and membrane fluidity, all leading to improvement in the appearance and structure of the skin. Emollients typically form a semi-permeable layer on the skin, which reduces or inhibits transepidermal water loss (TEWL). The third type of moisturisers are **occlusives**, i.e. hydrophobic substances such as mineral oils, paraffin and silicones. They physically block water loss by forming an inert, impermeable layer on the top of the skin, trapping the moisture in, which again results in the inhibition of transepidermal water loss. However, conventional, petrochemical-derived occlusives are generally not permitted in natural cosmetics due to their damaging environmental impacts.

Dermally applied glycerol penetrates into the skin, while physiologically produced glycerol is transported through aquaporins from sebaceous glands, and then accumulates throughout the whole stratum corneum thickness and establishes a reservoir of water. However, water absorption may not be the only mechanism of its action; it has also been shown to modify the water-binding properties of lipids and proteins in the stratum corneum, causing the expansion of corneocytes and the intercellular matrix, which improves skin barrier functions, as well as the moisturisation of the skin. Numerous human studies, as well as *in vitro* and animal experiments, have proven the exceptional moisturising effect of glycerol (2, 9).

Keep in mind, however, that the formulation of a moisturizer and the concentration of glycerol also play a role in a final outcome. Never use it undiluted, as applying anhydrous glycerol actually causes skin dehydration due to its high hygroscopy, i.e. the extraction of water from deeper layers of the epidermis, which usually results in the further drying of the skin (2).

OTHER EFFECTS OF GLYCEROL

Studies in human subjects have also shown:

- skin barrier repair,
- anti-irritant effect, and
- improvement of skin mechanical properties.

In vitro and animal studies have also shown promising results in wound healing, antimicrobial effect and protection against UV radiation (2, 7–9).

Let's dive into each in these effects.

Skin barrier function

As already mentioned, the outermost layer of our skin acts as the body's first line of defence against environmental stressors, such as mechanical, chemical and thermal stressors. An intact skin barrier is crucial for preventing excessive water loss and the penetration of exogenous substances that are potentially harmful to the body. These functions can only be performed by intact skin with the optimal organisation, both in terms of correct structural elements and interactions between corneocytes and intercellular lipids in the stratum corneum. Lipids can exist in liquid and solid crystalline phases, and the right balance between these two is a prerequisite for the desired functioning of the skin barrier. Environmental factors that cause skin dryness were shown to induce transition into the solid crystalline phase and glycerol was shown to prevent that transition. These research results are supported by a decrease in transepidermal water loss.

Anti-irritant effect

Glycerol's reduction of irritant properties of co-applied irritant agents has been confirmed by numerous studies, using different irritants (sodium lauryl sulphate, acetone, dimethyl sulfoxide, sodium hydroxide, etc.). One of the mechanisms was showed to be the reduction of pore radius in the stratum corneum, causing steric difficulties for the irritant to penetrate (into) the layer and impair skin's barrier function.

Mechanical properties of the skin

To function as a shield against mechanical stress, the skin needs intact mechanical properties. Studies have shown a correlation between the hydration of the stratum corneum and the mechanical attributes of the skin – reduced hydration accounts for impaired skin elasticity, deformability and epidermal plasticity. The application of glycerol had a promising effect on the improvement of measured parameters.

EVIDENCE-BASED FORMULATING

As a moisturising ingredient, glycerol is **typically used at concentrations of 1 to 5%** in cosmetic products for skin and hair care. Higher concentrations leave a sticky feeling on the skin, which is usually perceived as unpleasant. In products for skin and hair cleansing, glycerol is incorporated at concentrations of 5 to 10%, while concentrations of up to 50% may be used, in particular, in tooth gels, as it provides a pleasant, sweet taste (7).

The incorporation of glycerol in formulations has been justified in many **scientific studies**. In order to assess the level of skin hydration, a cream containing a glycerol concentration of 3% was used to compare control (untreated) and placebo (applying emollient without the addition of a moisturiser) groups. Using in vivo Raman spectroscopy, measurements of the skin following the topical application of a cream with glycerol showed a highly significant **increase in stratum corneum water content** (10).

Another study posed the research question of whether the increased hydration and regeneration of the stratum corneum by glycerol could be maintained during long-term use. The hypothesis was confirmed: a glycerol-containing O/W emulsion showed a significant **reduction in transepidermal water loss** and a significant increase of stratum corneum water content at three and six weeks compared with an O/W emulsion without glycerol (11).

In a study researching glycerol effects on chemically irritated skin, the latter was induced with the application of 10% sodium lauryl sulphate under occlusion for three hours. Glycerol aqueous solutions at different percentages were then applied as the irritant before skin hydration and transepidermal water loss were measured, and used to calculate the water holding capacity of the stratum corneum. It improved with a glycerol concentration of 2% and more, but was followed by a plateau at about 5%, indicating the saturation of the system. The demonstrated **improved water content** of the skin helps in the repair of the impaired skin barrier (12).

A randomised, double-blind study was carried out on patients with atopic dermatitis who were treated with a topical 20% glycerol preparation twice daily for four weeks. After a wash-out period, **stratum corneum hydration was significantly improved** and the barrier function of the skin was restored in subjects treated with glycerol-containing cream compared to those using a glycerol-free placebo (13).

The same type of study compared the effect of glycerol and urea on atopic patients with dry, eczematous skin. Subject were divided into three groups that were treated either with a cream containing 20% glycerol, the same cream base without glycerol (as a placebo) or a cream with 4% urea and 4% sodium chloride. Patients using the glycerol cream reported **fewer skin reactions** than patients using the urea cream. However, both creams with active ingredients showed equal effects on skin dryness compared to the placebo group. The study therefore suggested the advantage of glycerol-containing cream in the treatment of atopic patients (14).

FUTURE PROSPECTS

Glycerol undoubtedly exhibits various effects on skin functions. It is not only a 'good' moisturising cosmetic ingredient for healthy skin, but also suitable for the care of dry skin, a problem that is on the rise owing to urbanisation, pollution and other stress factors, and longer life expectancy. In broader terms, it acts as a topical therapeutic agent in the treatment of skin conditions with an altered epidermal barrier function, such as atopic and irritant dermatitis that pose a significant social and occupational impact. Options for its use are numerous, but one thing is for sure: glycerol deserves more attention and recognition.

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