Cooperation is everything – cosmetics and the skin microbiome

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Microorganisms perform extensive metabolic feats that depend on their individual enzyme equipment. They absorb substances, digest them and produce others, which they store or release to the outside world.

The skin microbiome is composed of many specialists, which in their entirety have a comparable metabolic universality as the skin cells. The continuity of their performance is an important prerequisite for healthy skin. Equally important are constant relationships among them. Although they populate the skin as competitors, they work together as a team – hand in hand.

The role of the microbiome can be compared to the service of cleaner fish, which are known to take care of keeping the skin of larger fish clean. What's more, in addition to this service, the balanced microbiome also protects the skin from non-resident, pathogenic colleagues from the outside world.

In addition, resident germs not only deal with skin components, but also with many substances that only get onto the skin through our modern high culture. These include working substances and cosmetics.

Besides the dermal food supply, the ambience in the form of physical factors plays a major role. Some germs love to have a roof over their heads and then really get going. This is especially true for anaerobic organisms that feel particularly comfortable under the protective cover of fatty substances – from cosmetics, for example – in an oxygen-poor atmosphere. The result: The original balance on the skin surface is upset.

Metabolic processes

Without going into the activities of individual microbial strains, virtually every known enzyme class is present in the skin microbiome as a whole. This makes it capable of almost all biochemical reactions:

- Oxidoreductases are responsible for oxidations and reductions.
- Transferases transfer functional groups from one substance to another. Among other things, they are involved in the degradation of fatty acids through β-oxidation.
- Hydrolases break down molecules with water, e.g. triglycerides into glycerol and acids.
- Lyases cleave bonds or whole molecules.
- Isomerases change the steric structure of molecules.
- Ligases link two molecules together.

It follows that cosmetic ingredients are broken down ("metabolised") by enzymes of the microbiome in the same way as by enzymes of the epidermis. The differences are only quantitative. If cosmetic ingredients inhibit or stimulate enzymes of the epidermis, which is especially true for many representatives of cosmeceuticals, then these effects usually apply equally to the microbiome.

Epidermis and microbiome

These clear facts ultimately lead to the realisation that all studies on the availability, effect and tolerability of ingredients reflect not only the activities of the epidermis, but the sum of the epidermis and microbiome – in other words, they are in principle more or less incorrectly related only to the epidermis. Thus, some macromolecules are attributed epidermal effects that physically cannot penetrate or permeate the skin at all without the preliminary work of the microbiome. In reality, they are partially or completely broken down by the microbiome beforehand. Well-known examples are:

- Hyaluronic acid – especially short-chain with a molecular weight of about 50,000 daltons. The skin barrier-compatible degradation product is N-acetyl glucosamine.
- Collagen preparations, proteins and polypeptides – degradation products are e.g. amino acids.
- Triglycerides – they are split into glycerol and free fatty acids, the latter furthermore partly oxidatively degraded to

short-chain fatty acids, which contribute to the low skin pH.
- Waxes – cleavage into wax alcohols and free fatty acids and their oxidative degradation products.

The paraffins and siloxanes ("silicones"), which are considered inert, are not metabolised by the epidermis or the microbiome and therefore remain on the skin surface for a very long time.

Physiological impact

In general, it can be concluded from the data available today that physiological ingredients in cosmetics are usually also good for the microbiome, whereas ingredients that are counterproductive for the skin also lead to problems and imbalances in the skin flora. The table lists typical examples:

Cosmetic ingredient	Effect on the skin	Effect on the microbiome
Preservatives	Irritations and allergies	Damage to the skin flora, danger of pathogenic germs developing resistance, similar to antibiotics.
Antioxidants	Inhibition of melanin formation	Inhibition of oxidoreductases that adjust the skin pH
Complexing agents such as EDTA	Impairment of enzymes containing heavy metals	Impairment of enzymes containing heavy metals
Emulsifiers and surfactants	Washing out natural barrier substances	Disturbance of the resident skin flora; the risk of infection by non-resident pathogenic germs such as fungal spores increases.
pH	Deviations from the skin pH are tolerated in small concentrations. A buffered pH must be in the skin-neutral range.	Enzymes are in an optimal working range at a skin-neutral, usually slightly acidic pH.
Tri-, di- and monoglycerides of vegetable oils	Ester cleavage by lipases; degradation of the released acids by oxidoreductases	Ester cleavage by lipases; degradation of the released acids by oxidoreductases
Stearic acid	Comedones formation at high concentration due to blockage of the sebaceous glands	Degradation at low concentration, stimulation of anaerobic germs at high concentration:
Shea butter	Support of the skin barrier through physiological sterols (analogous to cholesterol)	Behaviour similar to that towards cholesterol
Paraffins	Reduction of self-regeneration through occlusion	The stimulation of anaerobic germs provokes acne, rosacea and perioral dermatitis.
Vitamins	Depending on the vitamin	Vitamins are facultative substrates; if necessary, self-syntheses also take place (cf. vitamin K and vitamin B_{12} of the intestinal bacteria).
Boswellic acids	Inhibition of endogenous proteases in rosacea-prone skin	Inhibition of proteases of pathogenic germs (anti-inflammation)
Pentylene glycol	Oxidative degradation	Oxidative degradation
Alcohol	Drying of the skin at high concentration	Disruption of the microbiome in high concentration

(Excessive) hygiene measures, peelings and device-assisted treatments such as microdermabrasion weaken the protective function of the skin flora in favour of non-resident and possibly pathogenic germs. In these situations, on the one hand, the natural barrier must be restored as quickly as possible, and on the other hand, care must be taken to apply active ingredients in adequate concentrations to avoid side effects such as redness and irritation.

Compatibility with the skin flora

In addition to the very limited use of special probiotics, ideally physiological, microbiome-compatible barrier and sebum components are used in creams and counterproductive problem substances are excluded. As a rule, these are base formulations containing cholesterol or alternatively vegetable phytosterols, fatty acids such as palmitic acid or behenic acid, ceramides and squalene or alternatively squalane.

Another optimisation would be prebiotics, with which the growth of certain microbial strains – if desirable – is promoted, as is known from nutrition and the gut microbiome.
The water content of skin care products is a problem. O/W and, in a weakened form, W/O emulsions make preservation necessary in the form of preservatives according to the Cosmetic Regulation, natural substances with comparable properties, hypertonic water phases or, alternatively, sterile ampoules or pressurised doses. Meanwhile, the number of water-containing preparations claiming compatibility with the skin flora is growing.

Anhydrous products

Alternatives to the water-containing formulations are water-free oleogels based on triglycerides and phosphatidylcholine. Preservatives, emulsifiers and surfactants, complexing agents, paraffins and alcohols are omitted completely. Most oleogels are microbiome-compatible when used sparingly (!). However, many users still have to learn how to use them sparingly, as the concentration of skin care substances per ml is about three to four times higher compared to the usual water-based products – such as O/W emulsions.
Incidentally, oleogels do not concentrate water-soluble ingredients when the water contained in the product evaporates after application to the skin. Hypertonic concentrations are known to cause temporary, mostly harmless irritations (redness, burning) in O/W emulsions and sensitive skin.

Recognisable dissonances

It can be assumed that although the skin flora benefits from the metabolisation of cosmetic ingredients, it is limited in terms of its activities by the given skin surface on which it is located. But it can certainly make itself felt.
Apart from influences from hormonal balance, diet, smoking and medicines, odours, skin discolouration and inflammatory changes are an indication that something is wrong with the microbiome and/or the skin is not being treated properly:

- **Feet:** Under normal conditions, the local skin flora produces a faint odour due to the formation of isovaleric acid. The (too) frequent use of surfactant-based cleansers and the wearing of closed, i.e. occlusive footwear, as well as a tendency to perspire, leads to colonisation with bacteria that synthesise volatile sulphur-containing substances such as mercaptans, thioethers and thioesters. The unpleasant "sweaty foot" odour develops.
- **Ampits:** Odours and increased skin moisture result from high cleansing frequencies and depilation. The occlusive skin-to-skin situation also changes the composition of the skin flora here. The use of deodorant preparations is the consequence.
- **Scalp:** Dandruff is mostly caused by Malassezia yeast fungi. The fungi digest superficial fatty substances of the sebaceous glands and release fatty acids. The infection, which is provoked by daily washing with aggressive shampoos, is usually based on seborrhoea.
- **Skin discolouration:** In addition to hyper- and hypopigmentation, the causes of which can be traced back to local changes in melanin formation, AGE (Advanced Glycation Endproducts) or lipofuscin (oxidised protein-lipid complexes), one has to deal with discolourations caused by increased populations of the already mentioned Malassezia yeast fungi (pityriasis versicolor) belonging to the skin flora. Cosmetics can also play a role here. In this case, over-the-counter antimycotics such as terbinafine, an ergosterol synthesis inhibitor, can be a quick help.
- **Mycoses:** The risk of fungal infections on the feet and in the intimate region increases with exaggerated hygiene and tight-fitting, damp shoes and textiles.
- **Acne:** Triggers can be comedogenic substances in cosmetics that promote the proliferation of anaerobic germs and associated inflammation.
- **Rosacea:** With the exception of some oleogels with special additives, rosacea skin only tolerates low doses of lipid substances. If this framework condition is not respected, skin care results in increased growth of anaerobic germs, which quickly leads to efflorescences due to the reduced endowment of rosacea skin with antimicrobial peptides (AMP).
- **Perioral dermatitis (POD):** The same applies here as with rosacea. Even more: Acute POD tolerates at best aqueous active agent concentrates, but only if the skin surface is dry.
- **Barrier disorders:** A common cause is wash-out effects caused by surfactants (cleansers) and conventional emulsifiers (creams). The spectrum

ranges from dry to atopic skin including perianal barrier disorders. In all cases, skin care adapted to the specific conditions of the epidermis and the respective microbiome is necessary.

- **Skin pH:** Studies on the age-dependency of pH show an increase with age. The causes are unknown. Theoretically, the activities of the skin flora would have to change in parallel. However, it is also conceivable, since we are dealing with the evaluation of statistical data, that age-adapted habits play a role. Therefore, it is still unclear to what extent these changes should be counteracted by pH-adapted cosmetics.

Finally, in connection with the use of antioxidants, it should be noted that the amide and peptide structures found in the microbiome act as effective radical scavengers and in this way also contribute to the protection of the epidermis. One more reason to pay attention to its integrity.
Incidentally, mammals engage in intensive microbiome maintenance through their licking reflex by constantly redistributing germs.

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