

Cosmetic Oils in comparison: penetration and occlusion of paraffin oil and vegetable oils

By Dr. Matthias Hauser, J&J Consumer Healthcare Germany, 41470 Neuss

Introduction

The skin represents an effective barrier to the environment, which can be treated and supported by the topical application of skin care products, such as oils or oil-based formulations. Skin care products with a high lipid content are recommended for the care of dry skin and inflammatory skin conditions.¹ Pure oils (emollients) as well as oils integrated in diverse formulations are frequently applied for skin care being known for their capacity to moisturize the skin by supporting the native lipids of the stratum corneum and to provide a better barrier function.² Therefore, a deep penetration through the skin barrier is not compulsory necessary.

Nevertheless, there are since decades reports in the non-scientific literature about pure vegetable oils penetrating more deeply into the skin than paraffin oil (mineral oil) while others claim that paraffin oil is occlusive, clogs the pores and prevents the skin to breathe.³ However, searching through the scientific literature it is difficult to find arguments for both statements.^{1,4} Since vegetable as paraffin oils are often used e.g.in infant and child care products for cleansing as for caring purposes, the scientific answer to the question about the effect of different oils on the skin barrier is for formulators, users as for referrers of daily skin care products like midwives, nurses, paediatricians and dermatologists important.

Non-invasive methods

Therefore, appropriate *in vivo* methods are essential to characterize the penetration behaviour of vehicles and molecules aiming at continuous optimization and adaptation to special requirements like e.g. skin care products for dry or compromised skin. However, conventional *in vitro* measuring methods always require the removal of skin biopsies or the utilization of skin models, not displaying the real *in vivo* situation. Meanwhile non-invasive *in vivo* optical and spectroscopic techniques have enabled researchers to study substance penetration through skin in real time.⁵⁻¹⁰

Raman spectroscopy

In vivo Raman spectroscopy offers a non-invasive way to study cutaneous biochemical events at the molecular level because most biomolecules exhibit Raman signals. Raman spectra are divided into a lower energetic region (400-2000 cm^{-1}) and a higher energetic region (2500-4000 cm^{-1}). The latter region carries signals due to high frequency stretching vibrations of the very light protons, such as those present in OH—,NH—, and CH— groups. This region allows for separated measurement of signals due to water, lipids (as in oils), and proteins.

Recently, Stamatas et al. (2008) used *in vivo* confocal Raman micro-spectroscopy to test the efficacy of paraffin oil and two vegetable oils (almond, jojoba) concerning skin penetration and occlusion.⁵ In the study it was observed that the three oils used penetrated into the skin of 9 adults and 7 infants only into the top layers of the stratum corneum (up to 6-8 μm) and in the same extent. By measuring the swelling of the corneocytes they discovered no difference in terms of occlusion of the skin between vegetable oils and paraffin oil. Additionally they couldn't observe a difference in baby versus adult skin neither in terms of occlusion nor lipid penetration depth.

Transepidermal water loss (TEWL)

The TEWL measurement has become an important non-invasive tool in dermatology and cosmetology and is generally appreciated as a device for the monitoring of changes in the barrier function of the stratum corneum¹¹. In intact skin, TEWL values are rather low, where as impaired skin provides increased values leading to decreasing values when the barrier recovers.

Laser scanning microscopy

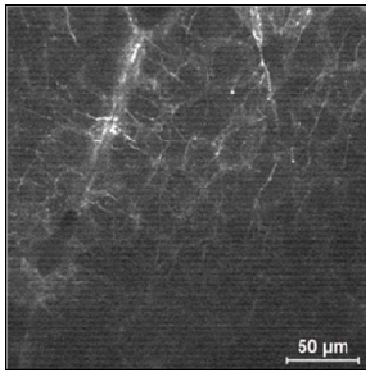
Another non-invasive optical method is *in vivo* laser scanning microscopy (LSM, in reflectance or fluorescence mode) which is highly selective and sensitive and has also been used to study the effect of topicals on the living epidermis and dermis.⁷⁻⁹ Because of the permeability of corneocytes to radiation in the visible spectrum (400-700 nm), this method is particularly well suited for analysing penetration of substances into the cutaneous layer. The method can be used to assess intercellular penetration of fluorescent or fluorescence-labeled substances within the lipid layer.

Patzelt et al. (2011) used *in vivo* laser scanning microscopy and TEWL measurements to investigate and compare the penetration of paraffin oil (mineral oil) and several vegetable oils into the skin barrier and their occlusion capacity, respectively.¹⁰ Pure petrolatum served as a positive control known for intense skin occlusion. Six healthy volunteers aged between 25 and 50 years were involved in the study. Volunteers were instructed not to utilize any skin care products at least 24 h and not to bath or shower at least 4 h previous to the beginning of the measurements. The oils used beside paraffin oil were jojoba, soybean, avocado and almond oil, representing different chemistry (fatty acid composition, unsaponifiables) and by this having different viscosity profiles, which in theory should result in diverse penetration behaviour. The food dye curcumin, which exhibits intensive fluorescence after excitation at 488 nm, was added to the oils to visualise their penetration and distribution in skin. The measurements with LSM and Tewameter™ for the TEWL happened before and 30 min after application and after the remaining oil has been wiped off.

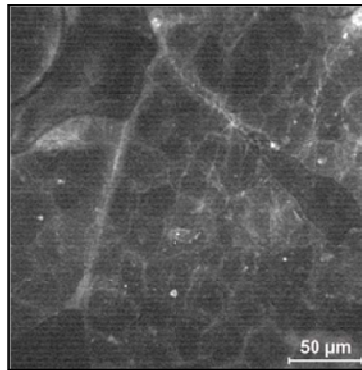
In vivo LSM revealed weak fluorescence signals in the study of Patzelt et al. for all topically applied substances which indicated bulk of each substance remained on skin's surface or was removed after wiping skin. Substance penetration appeared to be limited to the 2 uppermost layers of corneocytes. Beneath the stratum corneum, no fluorescence was observed. Representative LSM images (equivalent scanning depth) post application of oils and petrolatum are shown in Figure 1. In most volunteers fluorescence from the dye curcumin was only detectable on the skin's surface and in lipid layers surrounding the first few layers of corneocytes. Soybean and almond oil had the deepest penetration into the stratum corneum down to its third layer. After application of jojoba oil (Figure 1A), avocado oil (Figure 1D), and paraffin oil (Figure 1E), fluorescence was only detected on skin's surface and in lipids around the first few corneocyte layers. Petrolatum (Figure 1F) formed a homogenous protective film on the surface of skin, preventing sweat from penetrating into the stratum corneum and was not visible in upper corneocyte layers.

Interestingly despite quite different oil chemistry the penetration of vegetable oils vs. paraffin oil was comparable. Even among the vegetable oils there was no huge penetration difference as the composition in terms of type and amount of fatty acids with their specific extent of unsaturation would let someone expect.

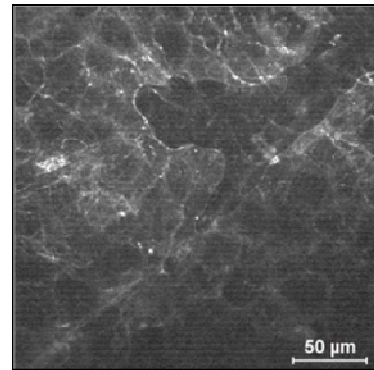
1A: Jojoba oil



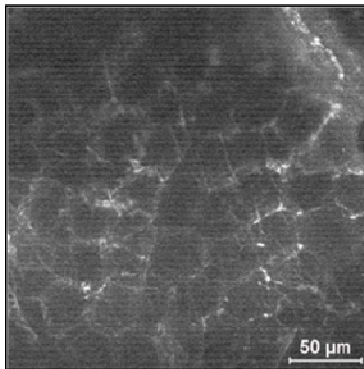
1B: Soybean oil



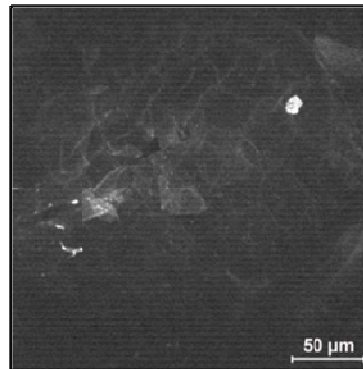
1C: Almond oil



1D: Avocado oil



1E: Paraffin oil



1F: Petrolatum

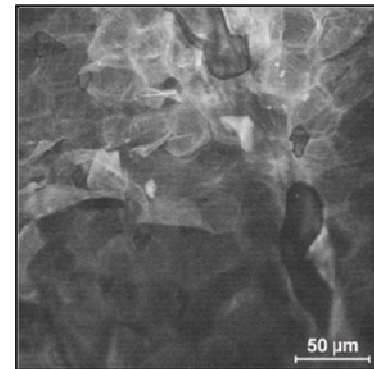


Figure 1: Distribution of jojoba (A), soybean (B), almond (C), avocado (D), paraffin (mineral) oil (E), and petrolatum (F) on skin of participants as obtained using in vivo LSM after 30 min oil application. Oils and petrolatum are only visible in the uppermost layers of the stratum corneum.

Transepidermal water loss

Mean values (\pm standard deviation) for skin before and 30 minutes after substance application are shown in **Table 1**. Known from previous experiences a difference in TEWL values after versus before treatment of $\leq 8\%$ could be neglected, because of no practical relevance.

After application of oils, TEWL values decreased for all substances except jojoba oil, indicating formation of a protective film on skin's surface. Petrolatum caused as expected the greatest reduction in TEWL values post application on skin. Differences in pre- and post-treatment TEWL values were statistically significant for all substances except jojoba oil. Almond oil showed an even

greater impact on the TEWL than paraffin oil. Nevertheless the TEWL Δ -values of all oils are in the same dimension compared to petrolatum.

Applied substance	TEWL values ($\text{g}\times\text{m}^{-2}\text{h}^{-1}$)		Difference between treated/untreated skin	Statistical significance
	Previous to treatment	30-min post treatment		
Almond oil	11.82 \pm 1.35	10.67 \pm 1.54	-9.67%	$P<0.05$
Avocado oil	11.70 \pm 1.61	9.93 \pm 2.22	-15.79%	$P<0.05$
Jojoba oil	11.82 \pm 2.18	11.82 \pm 2.68	-0.35%	$P>0.05$
Paraffin oil	11.95 \pm 1.54	10.70 \pm 1.78	-10.66%	$P<0.05$
Soybean oil	10.78 \pm 2.03	9.88 \pm 2.06	-8.63%	$P<0.05$
Petrolatum	10.95 \pm 2.10	5.08 \pm 1.78	-52.83%	$P<0.05$

TEWL, transepidermal water loss.

Table 1. TEWL values before and after topical application of oils and petrolatum.

Outcome

The studies as described above allow to draw a sketch for the behaviour of oils on skin and their penetration into skin. Figure 2 shows the difference, 2A for vegetable oils, 2B for paraffin oil. In both cases the oil is forming a more or less close layer on top of the skin, still allowing the skin to breathe as TEWL values indicate. Also, both oil types penetrate into the upper skin layers of the stratum corneum. However, 2A illustrates that vegetable oils due to their composition being similar to skin lipids i.e. skin compatible are taken up by the skin through enzymatic decomposition. That is what gives the well-known direct caring effect for e.g. dry and cracked skin. In contrast 2B shows that cosmetic paraffin oil - usually used in pharmaceutical grade with only saturated hydrocarbon chains and thus being chemically inert - is not metabolized while penetrating the upper skin layers of stratum corneum. So, paraffin oil, also lacking in active constituents compared to vegetable oils, does not have a direct caring effect, because it does not have a nutritional

benefit for the skin. In contrast vegetable oils are known and often preferred for direct caring of skin due to the fact that they contain important components like triglycerides, flavonoids, phytosterols and tocopherols.² Variations of oil compositions for sure exist dependant on their origin, breeding, harvest and processing. Also a lot is written already about the undisputable benefits of vegetable oils in terms of their support of the prostaglandine synthesis and the barrier function due to their content of essential fatty acids.^{12,13} Nevertheless, and this is valid for both oil types, mineral as vegetable based: by forming a thin protective layer on skin they do keep moisture in skin and thus deliver an indirect caring effect. Paraffin oil being used on wet skin has even shown an effect of locking moisture in skin about 10 times more than many lotions and creams.

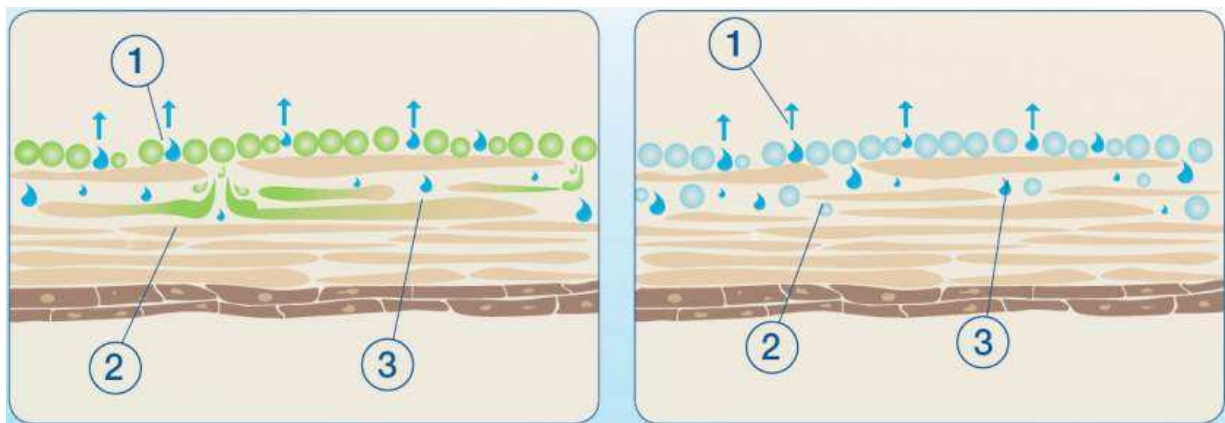


Figure 2: penetration of vegetable oils (A) and paraffin oil (B) into skin.

Conclusion

Raman, LSM and TEWL are appropriate *in vivo* methods for assessment of skin penetration and occlusion after topical application of oils. In both studies paraffin (mineral) oil and vegetable oils penetrated only into the upper layers of the stratum corneum. After application of paraffin and vegetable oils, TEWL values decreased, indicating partial occlusion of skin's surface and moisture retention. As expected, highest decrease in TEWL values was observed after petrolatum application (known occlusive agent). No statistical difference was visible between vegetable oils and paraffin oil, both types still allowing the skin to breathe and not clogging the pores.

Both oil types protect the skin and have a semi-occlusive effect. While vegetable oils are partly metabolized and their constituents integrated into the skin barrier, paraffin oil is staying inert. Thus,

the effect on TEWL reduction, means moisture retention, lasts longer with paraffin oil and is a clear benefit of it. The recommendation for one or the other oil type depends on skin type, intended use, body area and also tendency for allergies. Vegetable oils are unfortunately quite often used in the cold pressed form which can due to their protein constituents create allergies, while inert paraffin oil is recommended by dermatologists for the use on allergic and atopic skin.

Additional studies are still needed to learn more about oils when used in combination with other ingredients as part of complete cosmetic formulations.

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