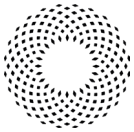
CODEX
BEAUTY LABS

Chapter: Sebum Measurement

SECTIONS



01 What is Sebum and where does it come from?

Sebum is a sticky, oily substance produced by the body's sebaceous glands which are located in the middle layers of the skin, near hair follicles. More particularly, sebum is a light-yellow viscous fluid, comprised of: from about 30-50% glycerides; from about 15-30% fatty acids; from about 26-30% waxes; from about 1.5-2.5% cholesterol; and from about 12-20% squalene.[1] A pictorial representation of the composition of Sebum is shown in Figure 1 below.

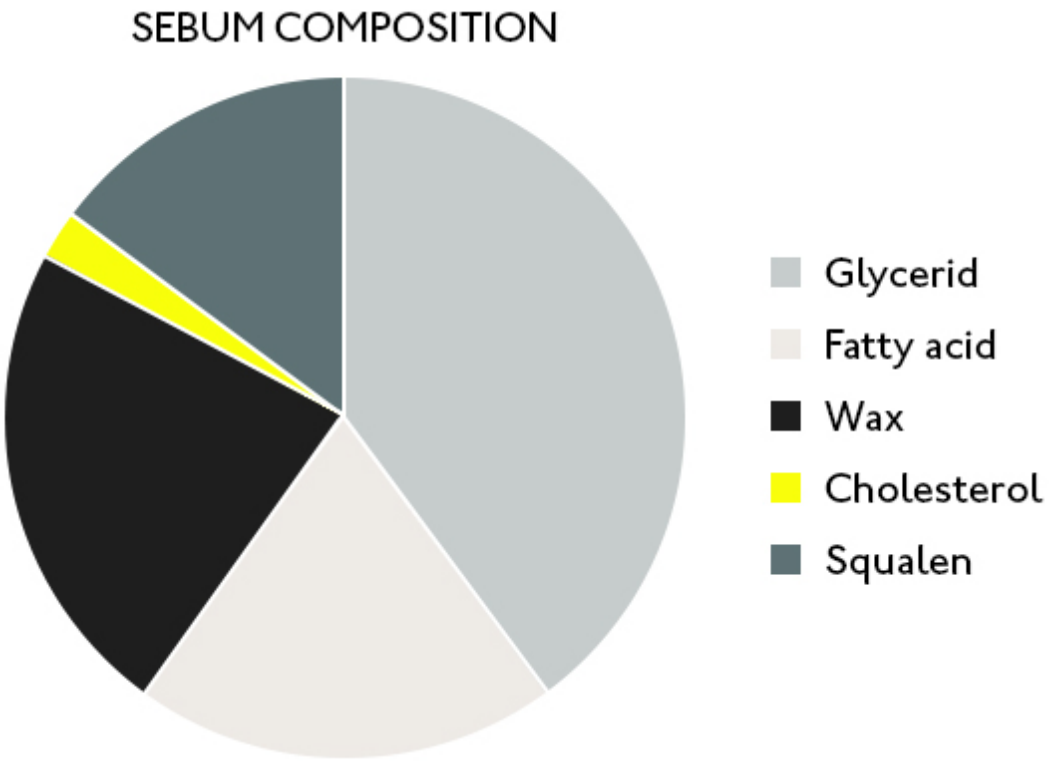


Figure 1. The composition of Sebum. After [1]

Sebum production is mainly influenced by androgens (hormones that play a role in male traits and reproductive activity) and varies among individuals and races with the average production rate in adults being approximately 1 mg/10 cm2 every 3 hours. Sebum production of less than 0.5 mg/10 cm2 every 3 hours is associated with dry skin, whereas a value of 1.5-4.0 mg/10 cm2 every 3 hours is associated with seborrhea.[2]

A sebaceous gland, shown in Figure 2 below, is a microscopic exocrine gland in the skin that opens into a hair follicle to secrete the oily/waxy matter called sebum, which lubricates the hair and skin of mammals. In humans, sebaceous glands are mostly located on the face and scalp but are also found on other parts of the skin with the exception of the palms of the hands and soles of the feet. Human skin has an average of 2,000,000 sebaceous glands, distributed with a density of approximately 400 to 900 glands per cm^2 on the face.2 In the eyelids, meibomian glands (a.k.a., tarsal glands) are a type of sebaceous gland that secretes a special type of oil (meibum) which together with water and mucus form the three layers of a tear film that keeps one's eyes moist.

Within the areola that surrounds the female nipple are areolar glands which secrete sebum for lubricating the nipple.[3]

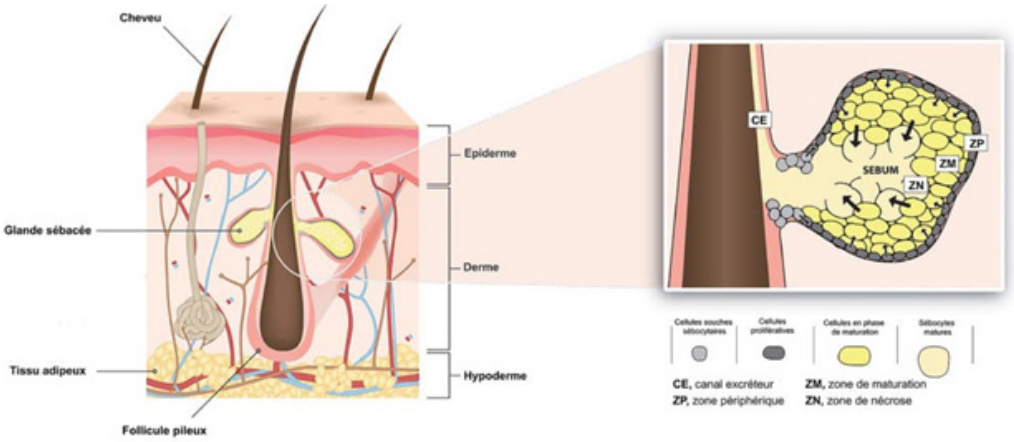


Figure 2. A Sebaceous gland. The sebaceous gland is associated with a hair follicle, forming the pilosebaceous unit. Located in the dermis, the sebaceous gland is connected to the hair follicle by the excretory duct. Sebum is secreted along the hair root and up to the skin surface via this canal After [1]

02 Why is Sebum important?

Secretion of sebum by the body supports skin health in several important ways:

- Hydration: Although sebum is essential for pliable skin, the amount secreted must be properly balanced in order to prevent skin irritation.
- Antibacterial protection: The lipids (oils) secreted by sebaceous glands help to create a slightly acidic film (a.k.a. acid mantle) on the skin surface having a pH of about 4.5 to 6.0 which helps to defend the skin against pathogenic bacteria, viruses, and other microbes.
- Antifungal protection: Sebum has been shown to prevent fungal infections such as ringworm, which may explain why young children who release little or no sebum are especially susceptible to this skin disorder.
- Sun protection: Squalene has been shown to protect against sunburn and the damage caused by ultraviolet (UV) rays.

Besides helping the skin, sebum production also seems to support heart health. Researchers believe that a major benefit of sebum secretion is that the process helps the body to eliminate excess lipids and cholesterol, which can block arteries and cause heart disease.[4]

Oily skin is caused by large quantities of sebum produced by the sebaceous glands that fill the follicular reservoir, and then spill over onto skin's surface. It has been noted that dry and oily skin are not mutually exclusive in that they can exist contemporaneously in certain areas of the face, a skin type phenomenon commonly referred to as "combination" skin. This skin type, however, is not always readily perceived because sebum oftentimes fills the space between flakes of dead skin residing on the face, thereby masking this duality.

Overproduction of sebum is one of the main causes of acne (acne vulgaris). Though acne is most common in teenagers, whose excess sebum production is driven by their body's hormonal changes, people of all ages tend to periodically suffer from this condition. Although severe cases of acne can cause serious illness, its effects usually result in discomfort caused by persistent infections and skin irritation, together with the negative impact acne has on one's appearance and the difficulty it poses when applying makeup and skincare products. The American Academy of Dermatology offers succinct advice regarding the care of acne and the application of cosmetics for those that suffer from this condition.5 For these and other reasons, the measurement and objective quantification of sebum excretion/production is considered important to both dermatologists and cosmetologists.

03 How is Sebum measured and what exactly is quantified?

Although numerous methodologies have been employed to measure sebum production, **we will only highlight some of the most popular ones. For more full, in-depth coverage the reader is invited to seek out more comprehensive references dedicated to this subject (e.g. references 6,7,8).**

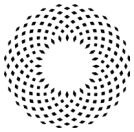
Prior to describing sebum measurement methods and devices, it might be helpful to note some of the characteristics of sebum/sebaceous glands that are often the focus of these measurements. The measurement of sebum/sebaceous gland properties is oftentimes focused on several parameters. Although the list of parameters evaluated is not necessarily uniform amongst all the references, those most commonly looked at include: casual level, secretion rate, sebum replacement time, density of sebum-enriched reservoirs, instant sebum delivery, and follicular excretion rate. It should be noted that all these parameters cannot currently be measured with a single method/device.

- Casual Level. The casual level is defined as the "equilibrium" or static level of sebum on a person's skin at any given time. This level ranges from 100 μg/cm2 -700 μg/cm2 on the forehead of an adult. Clinically, it is oftentimes measured by stripping the skin of existing sebum and then waiting a predetermined amount of time prior to measuring sebum levels over the area.

- Secretion Rate. The sebum secretion rate (SSR) is an important measurement for both the dermatologist and the cosmetologist. This is because sebum secretion rate refers to the amount of sebum secreted during a defined period of time over a given area of skin and this quantity reflects on many aspects of skin health. SSR correlates well with acne and a history of acne.

- Sebum Replacement Time. This represents the amount of time required to achieve a casual level of sebum after it has been cleansed from the skin surface. This measurement is apparently less popular than others owing to the difficulty in getting a precise measurement, though this may soon be resolved.

- Density of Sebum-Enriched Reservoirs. This is almost definitional as it represents the density (number per unit area) of follicular reservoirs enriched in sebum. This value is determined in a few different ways, but the most common method involves pressing specialized tape or plastic onto the skin and counting the number of spots imprinted onto the tape.



- Instant Sebum Delivery. This is an experimental and mathematical technique used to estimate the quantity of sebum leaking from follicular reservoirs. Measurements are made of the total area of spots (TAS) or droplets of sebum measured in an area of tape applied onto the skin. The total cumulative area of spots measured over time, in one-hour intervals, is plotted – typically as a straight line. The extrapolated value at time zero represents the instant sebum delivery value. (see Figure 3)

- Follicular Excretion Rate. This value is related to instant sebum delivery. Specifically, using the same mathematical and experimental technique described above, the slope of the TAS vs. Time line is called the follicular excretion rate (FER) which is a measure of the delivery rate of sebum from the follicular reservoirs. (see Figure 3)

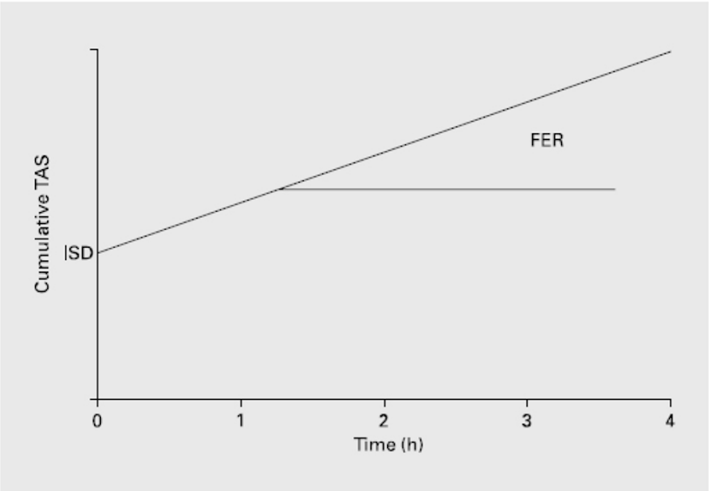


Figure 3. A graph of the cumulative TAS vs. Time with a straight line fitted to the data taken once/hour. The value at time = 0 represents instant sebum delivery, and the slope of the line is referred to as the follicular excretion rate (FER). After [6].

One of the oldest (dating back to at least 1936[9a]) techniques for measuring sebum involves the use of a solvent on the skin. In order to characterize the quantity of sebum present at a specific location on the skin, a hollow tube or "cup" with a known diameter is placed on the skin, after which a known quantity of solvent is poured into the cup's chamber. The solvent is then collected after a few minutes and allowed to evaporate, at which point the remaining sebum is weighed. This method is meant to estimate the casual level.

A variant of this technique, which reportedly dates back to 1886[9b], involves scrubbing sebum from the surface of the skin with a pad or sponge and then extracting the sebum from the pad/sponge with a solvent.[6] The solvent is then evaporated and the remaining sebum, weighed. This technique can also be carried out using cigarette or other absorbent paper. Here, the skin is first cleansed to remove surface lipids after which the paper is applied onto the skin and allowed to remain in place for approximately 3 hours. The sebum/lipids are then extracted with a solvent and weighed as per the previous technique. This technique gives an approximate sebum secretion rate. Though it requires attention to detail, is labor intensive and time consuming, this method apparently yielded most of the foundational knowledge on which SER is currently based.

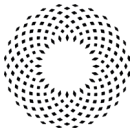
Another popular set of sebum measurement technique is based on placing a highly light scattering material (e.g., frosted glass or tape) against the skin. The material's surface, which is typically rough or porous, is used to collect the sebum. The collected sebum is then quantified by determining optical loss, thereby greatly simplifying the measurement. The first of these techniques 10 introduced in 1970 utilizes a frosted glass plate placed against the skin for approximately 30s. Typically, this type of plate is used to measure the casual level and the SER. The glass plate is then placed in between a light source and a detector to quantify the base level of light transmission. After contact with the skin, the degree of transmission increases because the lipid material bonds to the surface of the frosted glass, thereby smoothing its surface. This smoothed surface (post skin contact), when illuminated, results in an increase in light transmission because less of the light is scattered. This technique was commercialized by L'Oreal and referred to as a Lipometer.

A variant on the frosted glass of the Lipometer is Sebutape®[11,12]. Sebutapes are translucent, open-celled, microporous, hydrophobic films coated with an adhesive layer that adheres to the skin surface. Some Sebutape, however, work slowly and require being left on the skin for 1+ hours in order to quantify the number of sebum spots (TAS) that are used to determine the instant sebum delivery and the FER values. Other versions of this technique yield quicker results when it comes to measuring the casual rate and SER. Examples of devices using tapes with slow and fast response times are the C&K Sebufix and Sebumeter, respectively.

It is oftentimes helpful to see an overview of available measurements and methods of assessment. Figure 4 below is a chart showing which measurement techniques are typically employed for each parameter being quantified.

	Method of Assessment					
Parameter Under Study	Abs Pad	Solvent	Lipometer	Sebumeter	Sebutape	Sebufix
Casual Level		x	x	x		
Sebum Secretion Rate	x	x	x	x		
Sebum Replacement Time					x	x
Density of Sebum-Enriched Reservoirs					x	x
Instant Sebum Delivery					x	x
Follicular Excretion Rate					x	x

Figure 4. Chart of measurement techniques for each parameter being quantified.



04 More on Sebumeters

The C&K Sebumeter is arguably the most robust tool currently employed for characterization of Sebum, despite its limited applicability according to the chart in figure 4. The Sebumeter is in many ways an updated version of the Lipometer because it employs plastic tape, as opposed to frosted glass, as the contact material.

The Sebumeter comprises a plastic film cassette (Figure 97.1) and measuring unit having a spectrometer (Figure 97.2). Much of its appeal is based on its ease of use and the fact that results can be obtained almost in real time. The measurement takes place on a 64 mm2 measuring section of "tape" with a mirror mounted behind the tape, as is seen if Fig. 5a below. The cassette which holds the tape also houses the mirror so that the system requires no user alignment. After the user exposes the new segment of tape to be used, the spring-loaded cassette is then held against the skin for approximately 30s with the mechanics of the device being such that a consistent and constant pressure is applied onto the skin. Following application onto the skin, the cassette is inserted into an optical read-out system, as seen in Fig. 5b below.

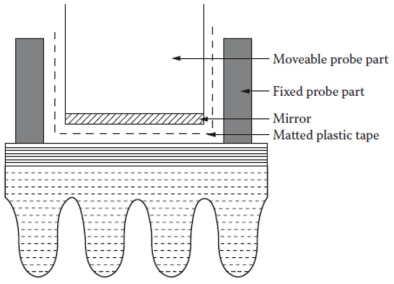


Figure 5a After[13]

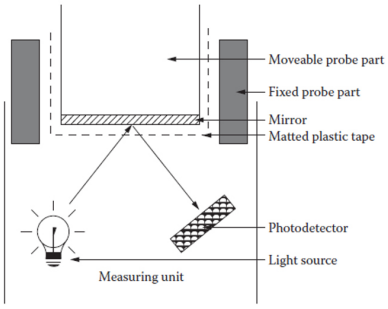


Figure 5b After[13]

Figure 5a is an outline of the device showing how the tape cassette plugs into the measuring apparatus. Figure 5b shows the optical path from the light source through the tape to the miror and back through the tape to the photodiode.

Using the manufacturer's guidelines for cleansing of the skin before use, the Sebumeter readily measures both casual level and SER. The device is so simple to operate that its use to evaluate sebum production has spread to numerous salons around the globe.

05 Reliability and repeatability

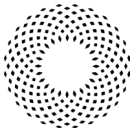
The reliability and repeatability of all the measurements and associated techniques described herein are all subject to their individual constraints, as well as more global physiological variations. The individual constraints regarding the solvent-based methods include, for example, the efficacy of the solvents used, the preparation of the skin surface, experimental accuracy (e.g., weighing), variations in the absorption capabilities of the papers/sponges used and the relative humidity of the environment during the testing process. The tape/photometric methods have similar issues with regards to surface preparation, variability of tape being used, consistency of experimental conditions (e.g., pressure applied onto the skin), optical alignment and intensity of light emitted by the device. The accuracy of each instrument is generally noted by the manufacturer, and more detailed analysis of these aspects of the devices can be found in the references mentioned above. For example, C&K identifies the degree of variability associated with measurements taken by the SM 815 Sebumeter as ± 5%.

06 Other methods summarized

While there are other techniques that have been historically used to try and quantify sebum production, there are a few newer, emerging techniques worth mentioning. For example, a more recent attempt at making accurate and reproducible measurements utilizes a fluorescent digital imaging system to acquire facial images to evaluate the distribution of sebum secretion on the face. The imaging system consists of a constant UV-A light source, digital color camera, and head positioning device.[14]

Another interesting approach developed by Delfin Technologies is the SebumScale15 which employs a disposable quartz crystal oscillator. The oscillator is placed in contact with the skin so that it can pick up sebum from its surface which causes a change in the oscillator's frequency. This change in frequency is then calibrated to arrive at an absolute sebum mass value.

Yet another purely optical method worth mentioning utilizes infrared spectroscopy for simultaneously and quantitatively measuring skin hydration and sebum levels by utilizing differential detection at three wavelengths: 1720, 1750, and 1770 nm. Each wavelength corresponds to lipid vibrational bands that lie "in between" the prominent water absorption bands. Skin sebum and hydration values on the forehead can be obtained using this technique. Experimental results obtained with this optical configuration show good correlation to results obtained using commercially available instruments such as the Corneometer used for hydration quantification and the Sebumeter.[16]



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