

Saponins in skin care

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Saponins are one of the most diversified substance classes in nature. Quite a number of saponins already have a long tradition of practical application and are well-known from folk medicine. The following article covers the different structures and effects of saponins.

Until soaps were produced by the chemical industry, people oriented themselves to nature. For cleansing purposes, for example, they used surface-active tensides from plants and extracts. Tensides are contained in the South American soap bark tree, in Indian soap nuts, in leguminous plants and in horse chestnuts (buckeyes) for instance. The roots of soapwort (alias latherwort, sweet Betty, goodbye summer etc.) contain about 2-5% of saponins.

The term "saponins" is derived from the Latin word "sapo" which means soap. Saponins consist of a lipophilic and water-insoluble steroid, steroid alkaloid or triterpene structure and ligated hydrophilic, water-soluble sugar molecules. Simultaneously lipophilic and hydrophilic substances are called amphiphilic substances – a feature shared with emulsifiers and tensides and the prerequisite for their cleansing characteristics. The mild synthetic sugar tensides used for cosmetic purposes are distant relatives of the saponins.

Glycosides

It is more the transition of water-insoluble to water-soluble substances what matters in terms of plant physiology rather than the cleansing properties of the saponins. Saponins belong to the glycosides that can easily be transported back and forth within the plants. Since the saponin base bodies – also called sapogenins – are characterised by a particularly complex ring structure, a single sugar molecule as in other glycosides is not enough to provide water-soluble features. Hence several sugar molecules are ligated. Sometimes also D-glucuronic acid, a saccharic acid, is ligated besides D-glucose, D-galactose and other mono saccharides. In the human kidneys by the way, D-glucuronic acid also transfers the no longer required and originally insoluble substances, such as e.g. medical drugs and their metabolic products into water-soluble substances so that they can be eliminated via urine.

Use and function

Saponins virtually occur in all above-ground and subterranean plant components as well as in the seeds. Hence they are frequently contained in aqueous and alcoholic extracts used in pharmaceutical tinctures, teas and in cosmetic preparations. There still is little knowledge about their function within the plants. Most of the saponins and sapogenins belong to the secondary plant metabolism. It includes compounds that are not vital for the plant organism, others are known as antibodies to ward off natural enemies or harmful monads for instance. The mildly poisonous solanin – the sapogenin is a steroid alkaloid – causes a green colouring of potato and tomato peels and protects the tubers from the attacks of microorganisms.

Sensitive skin

In the cosmetic field saponin-containing extracts have lived in the shadow for a long time. One of the reasons may be that there have repeatedly been rumours about the haemolytic activity of this compound class. Haemolytic substances are well-known for the potential risk of general irritations or irritations of the mucous membranes, similar to most of the tensides. Sodium dodecyl sulphate (SDS) for instance is a standard skin irritant and used for comparative studies in dermatology.

Experience however gives a different picture since saponin-containing extracts meanwhile have been successfully used for the care of eye contours and décolleté areas of sensitive skin and for the care of rosacea skin (see below) without showing any adverse effects. On the contrary: Some of the saponins even stabilize the superficial blood capillaries and tighten the surrounding connective tissue. The aescin of the horse chestnut (buckeye) already has a long history of medical application. It reduces the vascular permeability and is administered in the medical and cosmetic care of venous insufficiency and couperosis.

Moreover, haemolysis is measured in vitro. A decisive role in vivo, by contrast, play the indi-

vidual structure of the saponins, dosage, penetration, the reaction with barrier and tissue components (e.g. cholesterol) and the degradation through glycosidases or in other words, glycoside cleaving enzymes. Also the overall composition of the used extracts and the synergies of the single components are of significance. According to own studies, not a single case of skin intolerance has been reported among the test persons during in-house measurements with saponin-containing liposomal and nanodisperse active agent concentrates which are transported into the deeper skin layers due to the penetration enhancing carriers. By the way, glycosidases also occur in the human digestive tract and no problems have yet been reported with the consumption of saponin-rich fruit and vegetables.

It is a matter of fact that only a selection of saponins can be used for skin care purposes. Some of them are poisonous or already show strong systemic effects in low dosage. The seeds of common foxglove (also purple foxglove or lady's foxglove – *digitalis purpurea*) contain the poisonous digitonin for instance. Speaking of common foxglove, the *digitalis* glycosides digoxin and digitoxin gained from the leaves are cardiac agents and rather similar to saponins; instead of the monosaccharides of the saponins they contain deoxy sugar, though.

Multifunctional effects

Several saponins are characterized by a broad range of effects. Nevertheless only part of all the reports from folk medicine can be reconstructed today. This is aggravated by the fact, that the saponins in the extracts frequently are complex compounds with varying composition of the sugar molecules. Depending on the preparation of the extracts, sugars even are eliminated since some of the saponins are not resistant to heat or acids. In other words: Besides saponins there also are sapogenins. The ratio is crucial to the subsequent processing into a cosmetic preparation, particularly when modern carriers are used. Sapogenins can be processed with nanodispersions and saponins with liposomes. Similar to the haemolysis process, higher concentrations of saponins in liposomes can dissolve the phosphatidylcholine membranes of the liposomes due to their increased surface activity¹ – another parallel to the analogously reacting tensides.

¹ T. Paepenmüller, C. Müller-Goymann, Influence of Quil A on liposomal membranes, *International Journal of Pharmaceutics* 475, 138-145 (2014)

The saponins of plant sterols and the human cholesterol have identical triterpene base bodies. This structural relationship might be the reason for the fact that saponins and cholesterol form complexes that stick together through hydrogen bonds and van der Waals forces. Besides their cleansing features though, some of the saponins also gather along the cholesterol containing hairs and have conditioning effects and that is why they are successfully used in mild shampoos. The skin barrier benefits from the bonding of saponins to cholesterol since the residual sugars bind moisture on the surface. The moisture retention can still be enhanced by simultaneously applying hyaluronic acid.² Soy saponins frequently are used in this context. The content in soy is relatively high with about 43g/kg.³ Other and partly dubious extracts from sea cucumbers (INCI: Sea Cucumber Saponins) of the species *cucumaria frondosa*, starfish (or sea star – *asterias amurensis*; INCI: Starfish Saponins), great burnet (*Sanguisorba officinalis*; INCI: Ziyu Glycoside III), balloon flower roots (or Chinese/Japanese bellflower – *Platycodon grandiflorum*; INCI: Platycodin D) have been listed in the Inventory of Cosmetic Ingredients (CosIng) of the European Commission.

Speaking of Shampoos: Appropriate formulations of saponins generally form stable foam which can seasonally also be observed on surface waters in plant-rich environment. *Yucca* and *quillaja* saponins (soap bark tree) sometimes are used as „biotensides“ in foaming drinks.

The cholesterol-lowering effect of some of the saponins is interesting in the context of nutritional physiology; the effect obviously also is based on the above-mentioned interaction with cholesterol or in a similar way with the bile acids in the gastro-intestinal tract.⁴

The specialists

Repeatedly there have been reports on the immunostimulant effect of saponins such as

² A. Bürger, S. Gallinat, S. Fänger, A. Filbry und C. Mummert, Kosmetische Zubereitung mit Hyaluronsäure und Saponinen zur Behandlung von Hautalterungserscheinungen, DE 102005012554A1 (2005)

³ H.-D. Belitz, W. Grosch und P. Schieberle, *Lehrbuch der Lebensmittelchemie*, Springer-Verlag, Berlin, 6. Aufl., S. 787 (2008)

⁴ B. Watzl, Saponine – Charakteristik, Vorkommen, Aufnahme, Stoffwechsel und Wirkungen, *Ernährungs-Umschau* 48 (6), 251-253 (2001)

panax (or ginseng) saponins⁵ and also on the antioxidant effect of particular saponins. Most of these activities have been observed in vitro with cell cultures or other artificial systems. To which extent they actually are significant for skin care purposes has not yet been definitely proven. A number of saponins respectively saponin containing extracts have been successfully administered in the case of problems with capillary blood vessels and relating inflammatory processes such as couperosis and rosacea but also perioral dermatitis, though. A tightening influence on the connective tissue has also been observed.

Aescin is a saponin mixture of the horse chestnut (buckeye) which stabilizes superficial capillary blood vessels and the neighbouring connective tissue. Extracts are used for the care of the eye contours and the rosacea-prone skin, couperosis, oedemas and the care of the décolleté area. In medicine aescin is administered for the treatment of the leg veins.

Centella Asiatica (or gotu cola, Indian pennywort, Asian pennywort, tiger grass etc.): the saponin rich extract (among others asiaticoside alias madecassoside) is a component of skin-tightening preparations.

Ivy extract is used as a cough syrup and has secretolytic and bronchospasmolytic effects.⁶ It contains saponins such as α -Hederin and hederacoside B and C. In skin care the focus is on the inhibition of oedema formation (cf. butcher's broom). α -Hederin has vaso-constrictive effects.⁷ To which extent the extract is effective against cellulite still is in doubt.

Kigelia extracts (sausage tree)⁸ contain steroidal saponins (glycon: ruscogenin) as well as luteolin and 6-hydroxy-luteolin glycosides (vessel-toning, vaso-protective). Phytosterols and flavones are additional components so that the extract is predestined for tightening eye and décolleté preparations.

Butcher's broom extract (*Ruscus Aculeatus*) has astringent, tightening and vaso-stabilising

effects and is mainly used for the eye care. It contains saponins and sapogenins such as ruscin, ruscogenin and neo-ruscogenin and also is recommended against oedema, couperosis and rosacea. Modelages and packs both enhance the effects.

Common horsetail (or field horsetail - *Equisetum arvense*) also has tightening (connective tissue) and astringent effects due to its saponins (equisetonin⁹), flavonoids and silicic acid.

Concluding, also **glycyrrhizin** alias glycyrrhizic acid should be mentioned. While most of the saponins have a characteristic bitter taste, the glycyrrhizin of liquorice root extracts (*glycyrrhiza glabra*) is extremely sweet. It is the glycoside of glycyrrhetic acid and has anti-inflammatory effects. Liquorice extracts also are topically applied in the case of hyperpigmentations as the additionally contained glabridin, a flavonoid, inhibits the tyrosinase. The glycon of glycyrrhizic acid is glycyrrhetic acid and has lipolytic activity.¹⁰

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⁵ Cosmetic Ingredient Review: Safety Assessment of Panax spp. Root-Derived Ingredients as Used in Cosmetics, Final Report, October 5, 2012

⁶ F. Runkel, L. Prenner und H. Häberlein, Ein Beitrag zum Wirkmechanismus von Efeu, Pharmazeutische Zeitung online, Ausgabe 04, 2005

⁷ M. Wink, Ben-Erik van Wyk., C. Wink, Handbuch der giftigen und psychoaktiven Pflanzen, Wissenschaftliche Verlagsgesellschaft, Stuttgart 2008, S. 136

⁸ Sangita Saini, Harmeet Kaur, Bharat Verma, Ripudaman und S K Singh, *Kigelia africana* (Lam.) Benth. - An overview, Natural Product Radiance 8 (2), 190-197 (2009)

⁹ R. Hegnauer, Chemotaxonomie der Pflanzen: Eine Übersicht über die Verbreitung und die systematische Bedeutung der Pflanzenstoffe, Springer-Verlag 2013, S. 247

¹⁰ J. Bielenberg, Das kutane Fettgewebe – ein endokrines Organ, Ästhetische Dermatologie (mdm) 2015 (3), 32-39