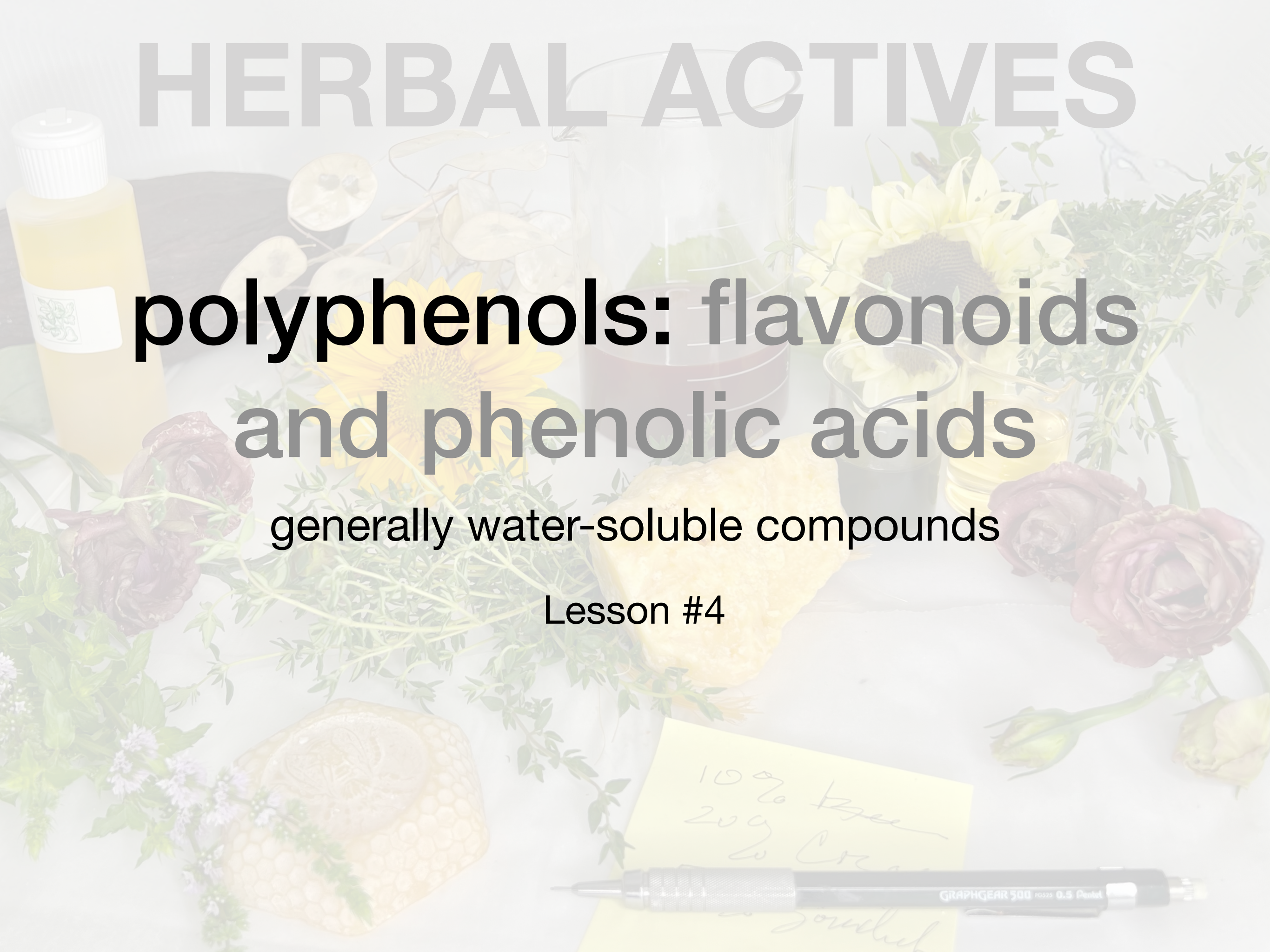


HERBAL ACTIVES

polyphenols: flavonoids **and phenolic acids**

generally water-soluble compounds

Lesson #4



polyphenols

Polyphenols; poly, meaning many phenol, referring to the multiple phenol aromatic rings with hydroxyl group structures attached.

These polyphenols are organic chemicals in plants that protect plant and cell tissues against damage from too much oxygen.

Polyphenols are synthesized exclusively by plants; however, animal fats can contain polyphenols when the animals are fed plant material that contains these compounds.

Polyphenols fall into broad categories: flavonoids and non-flavonoid compounds, phenolic acids, tannins, and lignans.



There are more than 8,000 different types of polyphenols, all exhibiting a range of antioxidant, anti-inflammatory, and antimicrobial properties.

Polyphenols are present in all botanically-based skincare ingredients and contribute to skin healing and protection.

Given the vast number of polyphenols, we will focus on those in the herbs and plants we regularly infuse into oils for use in skincare.

The number of common polyphenolic compounds then reduces to a manageable handful.

Given that the polyphenol compounds are primarily water-soluble, we will look at ways to facilitate their migration into the infusing process.

8,000!



solubility

The phenolic acids, flavonoids, and tannins are primarily hydrophilic, which means they are water-attracting and water-soluble.

Yet they are found in hydrophobic oils and fats and can migrate into infused oils during the maceration process.

Fragments of these compounds — those complexed with plant lipids — can migrate into oils during slow infusions or when using heat in the infusing process.

Amphiphilic means able to attract both water and oil. Phospholipids like lecithin are amphiphilic.

Natural emulsifiers and amphiphilic compounds in the infusing oil facilitate the transfer of polyphenolic plant compounds to the oil during the maceration process.



Polarity in terms of molecules relates to solubility, specifically in water or in oil.

This is related to the sharing of electrons between atoms and the ability to dissolve into a solution, such as water or oil.

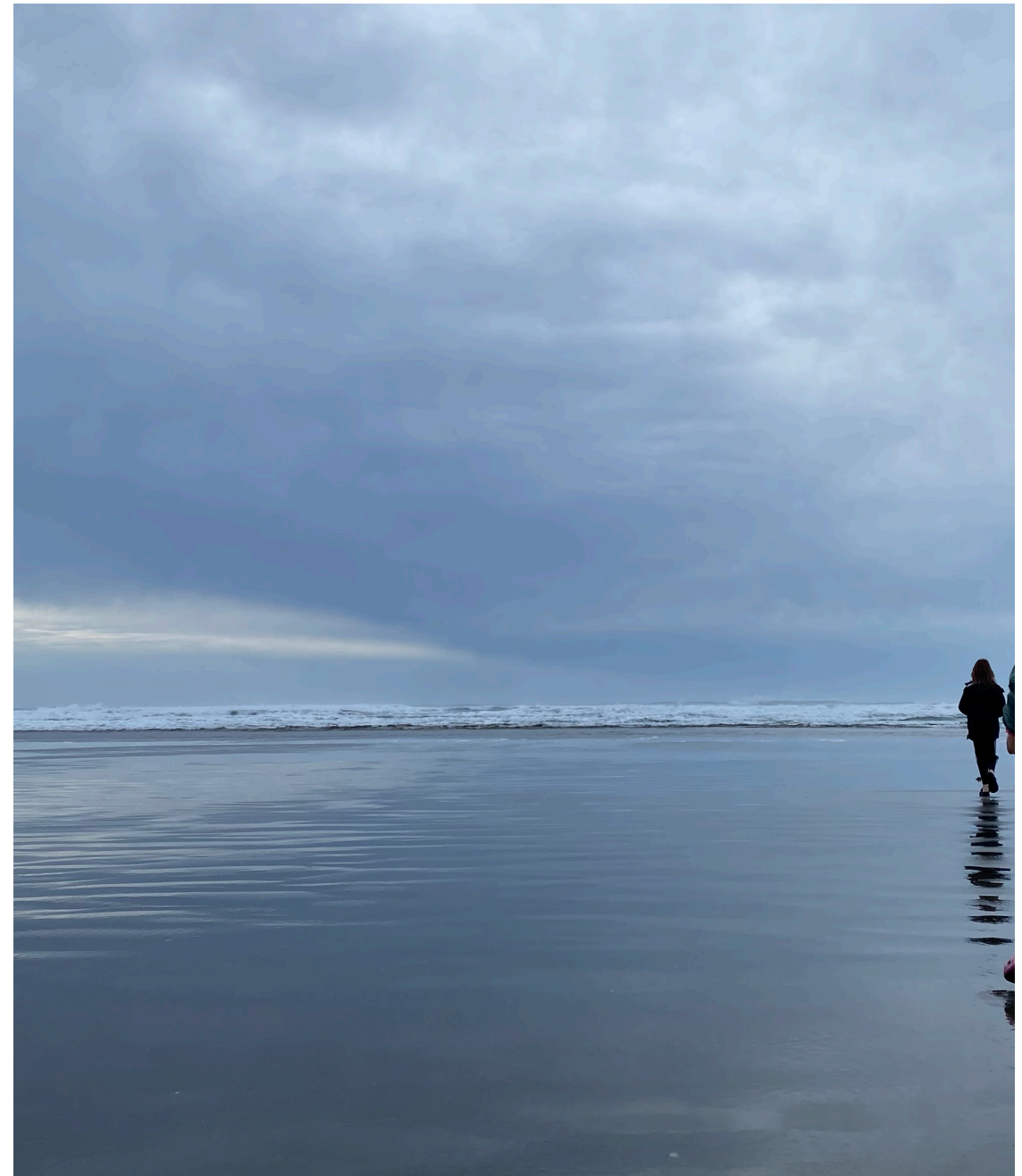
Polar compounds have uneven electron distributions, and we associate water-based solutions with the term polar.

Non-polar compounds have an even distribution, and for our purposes, these include lipids and oils, which exhibit solubility into an infusing oil.

An understanding of these solubility states matters when infusing into oil.

Not all plant compounds are oil-soluble; yet, these lipophilic compounds can migrate into the infusing oil under certain conditions.

polarity



into oil

Some flavonoids, such as quercetin and apigenin, are less polar and partially soluble in lipid compounds, mainly when heat or a long infusion method is used.

Phenolic compounds can form complexes with lipid compounds like sterols or phospholipids, allowing them to enter the oil phase and make their various treatment properties available in an oil infusion.

Infusions often contain tiny suspended plant particles or emulsified droplets — these can carry water-soluble compounds into the oil.

These are temporarily visible as faint cloudiness and will eventually settle at the bottom of a well-infused oil.

St. John's wort flowers



phospholipid

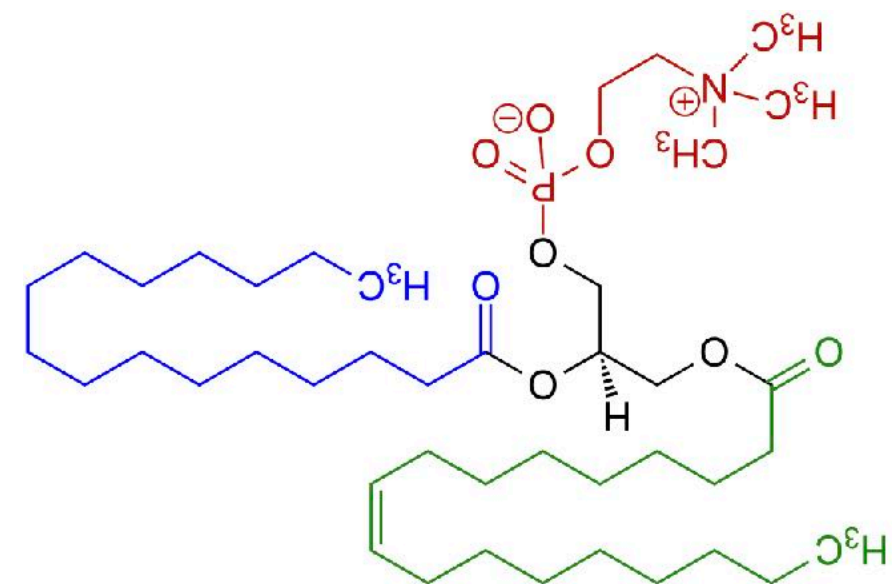
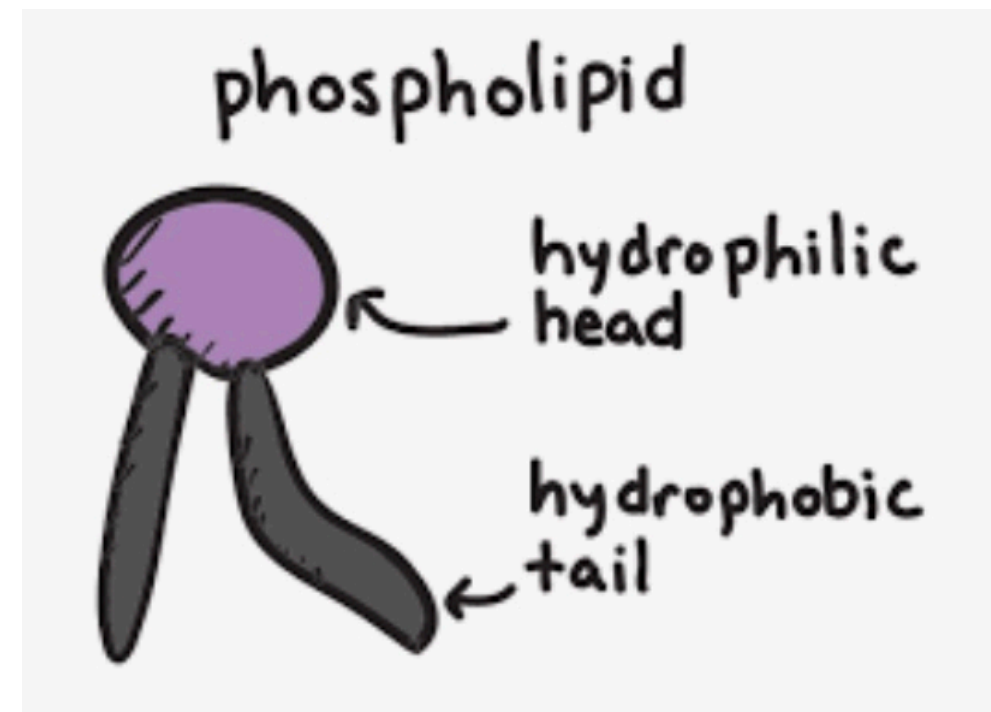
Infusing oils with a phospholipid component in the unsaponifiable fraction, or by adding a small percentage of lecithin to the infusing oil, can help encourage the hydrophilic —water-attracting— polyphenolic compounds to enter the infusing oil.

The amphiphilic nature of phospholipids and saponins helps move water-soluble compounds into an oil-based infusion.

Certain oils are more effective at this than others, but adding a small amount of lecithin can enhance the solubility of polar compounds in oil.

Utilizing the natural amphipathic nature of phospholipids can enhance infused oil potency.

Two drawing of phospholipids



amphiphilic oils

Phospholipids are often refined out of oils which is why the unrefined version is preferable for infusing polar compounds into oil.

Soybean oil, unrefined	1 - 3%
Sunflower oil, unrefined	1 - 3%
Wheat germ oil	2 - 5%
Rice bran oil	1 - 2%
Pumpkin seed, unrefined	1 - 2%
Corn oil, unrefined	1 - 2%
Hazelnut oil	0 .05 - 1%
Sacha inchi oil, unrefined	1%
Sesame oil, unrefined	0 .05 - 1%



infusing tips

Warm infusion ~40–60°C / 104–140°F increases the extraction of polyphenolic compounds without degrading them or significantly harming the oil.

Using phospholipid-rich oils like sunflower, lecithin-enriched soy, or unrefined sesame oil helps to carry small polar compounds from plant to oil.

Often oils visibly darken, take on the yellow/green tint from the plants due to polyphenol migration — this usually indicates the presence of carotenoids, flavones, or chlorophylls in the infused oil.



In the flavonoid group of polyphenols, there are six subclasses:

Flavonols

Anthocyanins

Flavanones

Flavones

Isoflavonoids

Chalcone

As a group they are:

- anti-oxidative
- anti-inflammatory
- anti-mutagenic
- anti-carcinogenic

And primarily, water-soluble, so we have to understand what will migrate into an oil infusion and how to create the environment for it to do so.

flavonoids



flavonols

Flavonols are the most studied flavonoid class and include kaempferol and quercetin, which are found in fruits and vegetables, tea, and red wine, and are highly antioxidant.

Quercetin is one of the strongest flavonoid antioxidants, protecting collagen and elastin from oxidative breakdown. It acts as an antihistamine-like capillary stabilizer and helps inhibit tyrosinase, reducing unwanted melanin production. Additionally, it is anti-inflammatory and UV protective.

Kaempferol - partially oil-soluble, anti-inflammatory, neutralizes free radicals, protects collagen and elastin, UV-protective, improves microcirculation, and reduces redness.

Myricetin - DNA protection, anti-aging, antioxidant, antimicrobial, and anti-fungal, helps preserve dermal structure and elasticity while protecting collagen.



Anthocyanins, primarily known for their role in plant pigmentation, are responsible for the vibrant colors in herbs, flowers, and fruits.

The color of anthocyanins varies with pH and can even give a blue cast to oils.

Found in red fruits such as berries, grapes, wine, cereals, purple corn, and vegetables such as cabbage, oils like Açaí, Buah merah,

They are highly antioxidant and able to scavenge free radicals.

Cyanidin is a colorant that protects collagen from UV and oxidative stress. Cyan is a shade of blue.

Delphinidin - Antioxidant, photoprotective, anti-inflammatory

Buah merah oil you can see the blue tint rather than an orange hue

anthocyanins



Flavones are widely present in leaves, flowers and fruits as glucosides, including celery, parsley, red peppers, chamomile, mint, and ginkgo biloba.

The peels of citrus fruits are also rich in flavones.

Nutritionally important and known for their antioxidant, anti-inflammatory, they also have potential anti-tumor properties.

Apigenin - Soothing, anti-itch, skin-calming, mildly estrogenic, wound healing and regenerative, neutralizes ROS

Luteolin - Anti-redness, antioxidant, anti-inflammatory, anti-allergic, protective of UVB induced damage

Parsley seed oil

flavones



Flavanones, known for their antioxidant and anti-inflammatory potential and play a significant role in reducing the risk of vascular disease.

As a type of flavonoid, they are aromatic, colorless ketones derived from flavones and can occur in plants as glycosides.

They are also responsible for the bitter taste found in the peels of fruits and vegetables, and are often citrus-based

Naringenin - Antioxidant, supports skin tone, vascular health

Hesperidin - Capillary-strengthening, anti-inflammatory

Grapefruit seed oil

flavanone



isoflavonoids

Isoflavonoids of the legume family, *Fabaceae*, with soybeans being a particularly rich source. Other sources include fava beans, chickpeas, and red clover.

Fenugreek contains several isoflavonoids, most notably genistein and daidzein, which form as phytoestrogens.

Genistein - Estrogenic support, anti-aging, collagen-stimulating, soy, red clover

Daidzein - Balances skin impacted by hormonal shifts, legumes, soy, red clover

Fenugreek seed oil



chalcone

Chalcone, as a flavonoid, is significant in tomatoes, pears, strawberries, bearberries, licorice, chamomile, angelica, ginger, and wheat products

Chalcones lead to the flavonoids, flavones, and flavonols, and we can consider them as flavonoids in raw form — often more reactive and sometimes more lipophilic than other flavonoids.

Xanthohumol - Anti-inflammatory, phyto-estrogenic, antimicrobial, found in Hops, *Humulus lupulus*

Isoliquiritigenin - Anti-inflammatory, skin lightening, antioxidant, found in licorice root

Butein - Strong antioxidant, reduces UV damage, collagen protection, and is found in small amounts in calendula and chamomile.

Hop flowers



phenolic acids

Phenolic acids are another broad group of plant compounds found in leaves and flowers, as well as in the unsaponifiable fractions of plant oils pressed from the seeds. These only partially transfer to infusing oils with care and careful handling.

- ***Ferulic acid**, a component of lignins and plant cell walls, may migrate in trace amounts with heat or into phospholipid-rich oils

- ***Caffeic acid** is a structural component of lignins, limited migration with warmth; and better transference with emulsifiers or phospholipids

- ***Chlorogenic acid** is found in comfrey, burdock, artichoke leaf, nettle, green coffee beans, and echinacea. anti-inflammatory and antimicrobial

- ***Rosmarinic acid**, an antioxidant and antimicrobial, can be moderately possible in warm infusion; found in lemon balm, rosemary

- ***Gallic acid**, an astringent compound, is insoluble in oil and is found in tannins and gallnuts; it may remain in sediment during infusion

caffeic acid

Caffeic acid is a type of phenolic acid, hydroxycinnamic acid, found in generous amounts in comfrey, basil, thyme, rosemary, echinacea, and calendula.

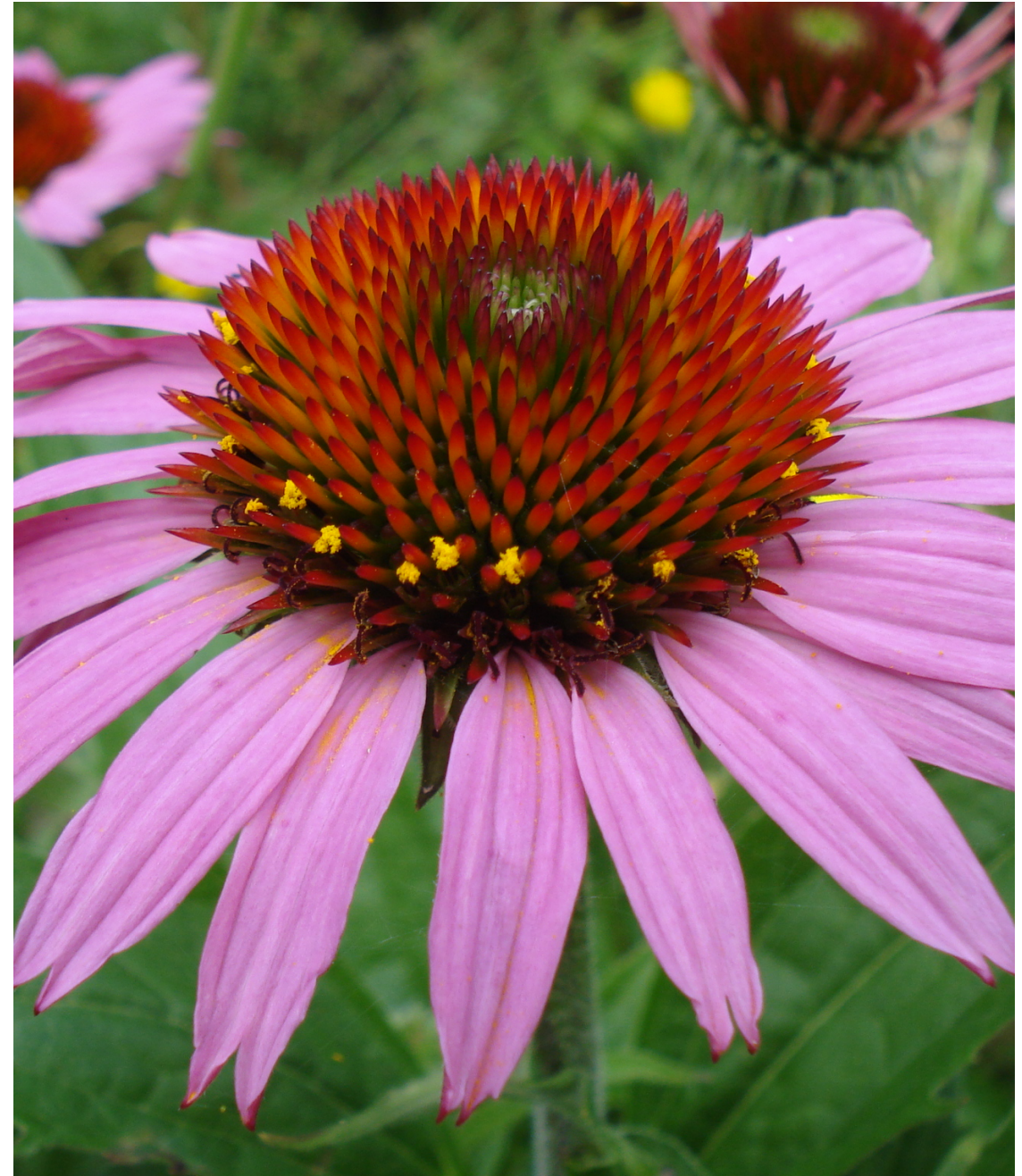
The acid scavenges free radicals, protecting against lipid peroxidation of tissues, while modulating and reducing irritation and redness as an anti-inflammatory.

Collagen is supported by inhibiting enzymes that degrade collagen and elastin.

Protection from UV-induced oxidative stress, helping to prevent and slow photoaging.

While caffeic acid is primarily hydrophilic, the compound can migrate into the infusing oil by using a long infusion time and gentle heat on fresh or only gently dried materials.

Echinacea purpurea



chlorogenic acid

Chlorogenic acid is found in comfrey, burdock, artichoke leaf, nettle, green coffee beans, and echinacea, and is especially abundant in the leaves and young aerial plant parts.

It is an ester of two phenolic acids, caffeic acid and quinic acid, and is primarily hydrophilic, but minor amounts can migrate into oil. Using phospholipid compounds will increase the infusion process.

Chlorogenic acid protects against UVB and stimulates wound healing by activating fibroblasts which aids tissue remodeling.

Anti-inflammatory and antimicrobial chlorogenic acid supports the natural functions of the skin, which slow premature aging and improve skin health.

Green coffee seed and oil



Ferulic acid is strongly antioxidant and anti-inflammatory. Its activity falls within the hydroxy-cinnamic acid group, as does caffeic acid.

Though primarily water-soluble, certain forms of ferulic acid can migrate into oils during the infusion process.

γ -oryzanol in rice bran oil is a complex of lipid-soluble ferulic acid esters found almost exclusively in rice bran oil and can help the plant to oil migration.

Its antioxidant actions scavenge free radicals, protecting the oil from rancidity and enhancing vitamin E stability.

Anti-inflammatory, ferulic acid calms redness and irritation, supports the collagen structure by protecting the rebuilding tissues from oxidative damage.

UV protective by absorbing UVB and UVA, which helps reduce UV-induced lipid peroxidation and improve hyperpigmentation.

Rice bran oil

ferulic acid



gallic acid

Gallic acid protects against the oxidation of lipids, proteins, and the breakdown of DNA, which is vital in anti-aging and wound repair.

Found in Witch hazel, pomegranate, green tea, oak bark, St. John's wort, astringent, antioxidant, antimicrobial, skin toning, and tightening.

Gallic acid neutralizes reactive oxygen species (ROS), preventing oxidative damage to skin cells.

Tones and tightens skin by binding to proteins, especially collagen and keratin, forming a protective film.

A compound, among others, that inhibits tyrosinase, an enzyme involved in melanin production, making it helpful in treating hyperpigmentation, melasma, or dark spots from scarring.

St. John's wort



rosmarinic acid

Rosmarinic acid is a polyphenolic compound classified as an ester of caffeic acid and is a potent antioxidant, anti-inflammatory, and antiviral compound.

Rosmarinic acid is one of the principal active components in lemon balm, *Melissa officinalis*, and other *Lamiaceae* plants like rosemary, sage, thyme, and perilla.

Antioxidant, able to scavenge reactive oxygen species, ROS, protecting skin lipids, and proteins, from oxidative stress. It also helps reduce UV-induced oxidative stress and inflammation in the skin.

Maintaining collagen integrity and slowing skin aging, rosmarinic acid works with flavonoids like luteolin and apigenin in oxidative defense of the skin.

The mild antimicrobial effect, especially against gram-positive bacteria, helps to prevent minor infections in compromised or inflamed skin.

Perilla, *Lamiaceae* family



four more phenolic acids

P-Coumaric acid is a Hydroxycinnamic acid found in chamomile, parsley, garlic, carrot, and oregano. It is an antioxidant that reduces inflammation and supports cellular repair.

Ellagic acid is related to gallic acid, found in Pomegranate, raspberry leaf, oak bark, and rose petals, and is UV-protective, promoting skin firmness and reduces oxidative stress.

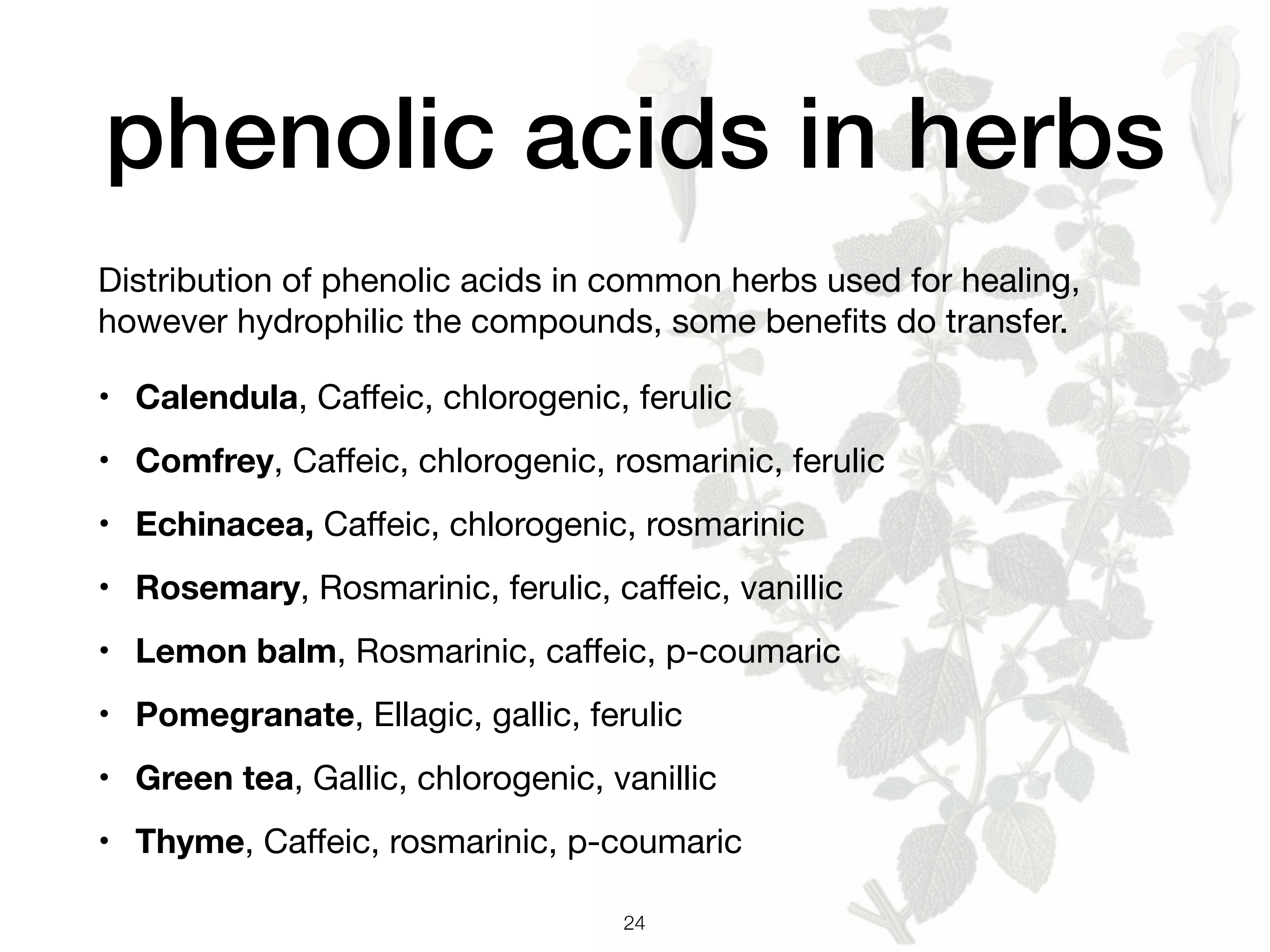
Vanillic acid is found in vanilla, angelica, green tea, and rhubarb. It is an antioxidant, a mild antimicrobial, and soothing for the skin.

Salicylic acid, a phenolic compound found in willow bark, *Salix*, and meadowsweet, *Filipendula*, is anti-inflammatory and used in acne and exfoliating preparations.

Queen Anne's Lace, *Dacus carota*



phenolic acids in herbs



Distribution of phenolic acids in common herbs used for healing, however hydrophilic the compounds, some benefits do transfer.

- **Calendula**, Caffeic, chlorogenic, ferulic
- **Comfrey**, Caffeic, chlorogenic, rosmarinic, ferulic
- **Echinacea**, Caffeic, chlorogenic, rosmarinic
- **Rosemary**, Rosmarinic, ferulic, caffeic, vanillic
- **Lemon balm**, Rosmarinic, caffeic, p-coumaric
- **Pomegranate**, Ellagic, gallic, ferulic
- **Green tea**, Gallic, chlorogenic, vanillic
- **Thyme**, Caffeic, rosmarinic, p-coumaric

hydrophilic migration

As phenolic compounds are primarily water-soluble, only small amounts can make their way into oil during the infusing process.

Techniques using warmth and an extended infusing period, plus employing amphiphilic compounds like lecithin, can encourage transference from plant to oil.

Warmth $\sim 40\text{--}60^{\circ}\text{C}$ / $104\text{--}140^{\circ}\text{F}$ increases the extraction of polyphenolic compounds without degrading them or significantly harming the oil.

I often opt for sun infusion for this reason, as the sun provides the controlled warmth that can help the process.

Infusing plant compounds into oils is a process that, when done with care, involves awareness of the plant's composition and what compounds will migrate into the oil.



partner with nature

Can we measure what compounds migrate into the oil? Yes, but laboratory fees are costly.

There are probable constituents that will be available in the final infusion, but no guarantees, as every crop harvested will differ slightly.

Examining infused oils for potency is possible, but each infusion will vary, and each desired compound will incur a cost to detect potency when sent to an examining lab.

I encourage you to take care in creating your infusions and resist the compulsion to measure each compound for viability.

Your infusions will reflect your care, the plants you have grown or wildcrafted, and the methods you use, and they will work to help care for and treat the skin.



