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Five waxes and an infinite range of textures

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The personal care industry has always been resilient, even during economic downturns.[1] As consumers evolve and adapt, so do their demands, and the days when beauty products only needed to deliver a result are gone. The natural ingredient demand has grown into a movement, where not only ingredients, but entire brands are proving their commitment to transparency, ethics, and sustainability.[2] The importance of connecting emotionally with the consumer is more present than ever, as the global pandemic has driven consumers to fear, skepticism, and economic insecurity.[3] A few ways in which we can make deeper connections is through encouraging a sense of wellness, community and self-care.

One way we, as formulators, can connect with consumers is by delivering innovative formulas with functionalities and textures that foster these positive feelings and make lasting impressions.[4] To do so, proper ingredient selection is key, and at Koster Keunen we believe natural waxes can deliver on all fronts.

Natural waxes deliver universally

Natural waxes are functional

Waxes are a very diverse class of organic compounds, with some key similarities. They are water-insoluble, solid mixtures of long-chain hydrocarbons and/or esters of higher fatty acids and alcohols. They become soft, pliable, and liquid when warm and variably hard when cold.[5] Their hydrophobic nature makes them ideal for use in cosmetic and OTC drug applications as film-formers that block trans-epidermal water loss in the stratum corneum.[6]

Natural waxes are sensory

As for sensory ingredients, waxes are commonly known for their thickening or structuring properties, but we have found after multiple texture studies (and years of formulation experience) they can offer a wide variety of textures depending on the nature of the wax and the formulation that contains it. This variety of textures will translate into different sensations when applied to the skin. In anhydrous systems, waxes interact with oils in different ways, producing jellies, sticks, transforming textures, creams, balms, etc. In emulsions waxes can thicken the formula, as well as affect product esthetics such as gloss, firmness, rub-out and after-feel.

EFFECT OR WAX ADDITION TO BALM BASE

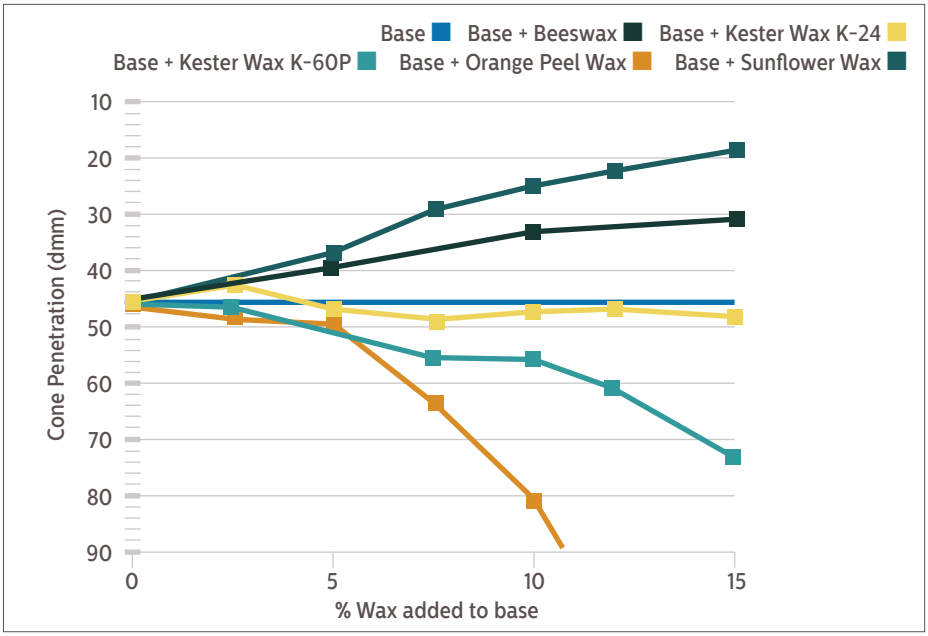

Figure 1: Gel study #1.

Natural waxes are traceable

Waxes can have varying degrees of 'naturalness', depending on the classification criteria. Regardless, whether they are extracted from natural resources or produced using natural feedstocks, waxes can be traced back to the source, making them attractive to both formulators and brands looking for transparency. Traceability, along with social, economic, and environmental factors, is an important aspect of sustainability.

Five natural waxes: overview

Sunflower wax: hard structure

Helianthus Annuus (Sunflower) Seed Wax is obtained from sunflower seeds through a very simple process of mechanical extraction, winterisation and purification. The chemical composition of Helianthus Annuus (Sunflower) Seed Wax is moderately complex. It consists of long-chain esters, 90% of which are esters of C16-24 fatty acids and C26-32 alcohols, and a small amount of free fatty alcohols and free fatty acids. The seed hull contains most of the wax found in a seed.[7]

In personal care, sunflower wax is mainly used in creating hard sticks, including lip balms, lipsticks, and deodorants. It provides structure to many systems, regardless of oil medium or presence of pigments/powders. It can also be used as a natural replacement for many petrochemical derived waxes, such as ozokerites, polyethylene or synthetic wax.

Beeswax: the multi-tasker

Beeswax is biosynthesised by the European honey bee (*Apis mellifera*) in response to environmental stimuli. It is an incredibly complex mixture of organic compounds, mainly long chain esters, hydrocarbons, polyesters, free fatty acids, and other minor components that make it unique.[8] Raw beeswax can be refined in varying degrees to produce commercially available grades, with applications in food (GRAS listed[9]), cosmetics and many other industries.

In personal care, beeswax is used for its oil gelling and viscosity building capabilities. It is an excellent choice when adding structure to lip balms and lipsticks, and it is also widely used in body care (emulsion creams and butters as well as body sticks like sunscreens), mascaras, and hair stylers (emulsions as well as anhydrous).

Polyhydroxystearic Acid (Kester Wax K-60P): creamy textures

Polyhydroxystearic acid is a polyester wax produced from renewable plant materials. Its chemistry consists of multiple repeating units with ester functional groups. Saturated polyesters are excellent plasticisers that impart flexibility and softness to harder, more brittle waxes and polymers.

In personal care, Kester Wax K-60P is used for its plasticising, film-forming, pigment wetting and viscosity modifying properties. It is an excellent choice in cosmetic sticks, as its plasticising properties add a creamy feeling and prevent issues including: sweating, brittleness, and grain formation. In emulsions it can build formula viscosity and leave a rich heavy feeling on the skin, without clogging pores (3rd party tested). It can also be a vegan alternative to beeswax.

Lauryl Laurate (Kester Wax K-24): Instant melt ester

Lauryl laurate is a mono-ester produced from renewable plant derived materials, with a very simple chemistry. In general, alkyl esters are hydrophobic materials with large molecular weight/chain length ranges, safe for use in cosmetics.[10] The low molecular weight and low melt point characteristic of lauryl laurate make its sensory profile more consistent with that of a liquid.

In personal care, Kester Wax K-24 is mainly used for its emollient properties and dry, silky after-feel. It is an excellent choice when adding slip and glide to stick products without compromising structure, including pencils, lipsticks, and sunscreen sticks. In face and body care, it promotes light feeling, low viscosity emulsions (serums and creams). It is also non-comedogenic and non-irritant (3rd party tested).

Orange Peel Wax: upcycled botanical emollient

Citrus Aurantium Dulcis (Orange) Peel Wax is a by-product from the production of orange essential oil and orange juice. The wax portion is obtained by steam distillation of the orange fruit peels, and later processed through physical methods only, like absorbents and filtration. The deodorisation process removes all terpenes and most of the essential oil components.[11]

The chemical composition of Orange Peel Wax is quite complex and different from other traditional waxes, consisting of approximately 50% unsaturated monoesters of unsaturated fatty acids and long-chain alcohols.[12]

In personal care, Orange Peel Wax is safe to use in all applications (non photo-toxic, 3rd party tested), with most applications being as an emollient, texture modifier, and a natural colorant and fragrance. It can also be used as an alternative to anhydrous lanolin, or as its vegan replacement.

SUNFLOWER WAX AND BEESWAX GELS. EFFECT OF MEDIUM.

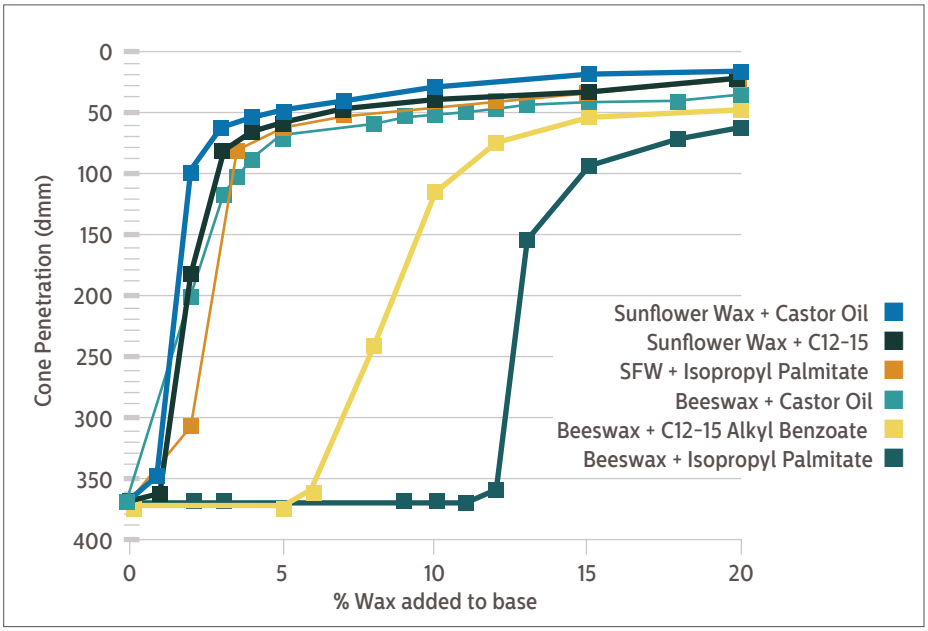

Figure 2: Gel study #2.

Formulating with waxes in anhydrous systems

The importance of gel hardness

Traditionally, waxes are used in cosmetics to thicken and structure oils by building stable gel networks. When certain waxes are heated above their melt point and combined with a suitable solvent (cosmetic esters including vegetable oils, paraffin oils, silicones, etc.) and then cooled to room temperature the resulting product is called an organogel. In these gels, the wax molecules are solvated by the liquid portion of the gel; upon cooling they self-assemble into a three-dimensional network where the liquid is entrapped within.[13] Many waxes thicken and structure oils in this manner and extensive data shows that gel hardness is proportional to percentage of wax. However, there are many nuances and exceptions. Some waxes do not thicken at all.

Gel study #1

In a series of experiments, we added increasing amounts of five different waxes to a simple lip balm base and recorded the resulting product hardness (by cone penetration).

From Figure 1, we see how efficiently sunflower wax produces hard gels, while beeswax builds structure at a slower rate. This phenomenon is

TABLE 1: WAX LEVELS AND COMBINATIONS

Hardness/Texture Profile	% Sunflower Wax	% Beeswax	% Kester Wax K-60P	% Kester Wax K-24	% Orange Peel Wax	Texture Categories
Flowable Liquid (Transparent)	0	0	< 5	< 40	< 30	Fluids, Sprays
Flowable Liquid with some Viscosity	0	1-5	0-10	<50	<50	Fluids, Drops, Oils
Semi-Solid (Pumpable)	0-5	0-10	0-15	QS	QS	Gels, Jellies
Soft Solids (Scoopable)	0-5	5-15	5-20	QS	QS	Balms, Butters Pastes
Solids	5-10	10-15	3-7	QS	QS	Bars, Sticks
Hard Solids (Unique Systems)	>10	>20	2-5	QS	QS	Pencils, Waxes
Function in Formulas	Increasing melt point and thermal stability, strong gelling agent	Structuring, film forming, plasticizing	Plasticizing, stabilizing, correcting incompatibilities	Emollience, slip, glide, dry non-greasy feel	Emollience, claims	
Sensory Descriptors Associated	Firm and hard, high slip	Firm but creamy, good payout	Soft and creamy, high pick-up / payout, some tack	Glossy, slippery, non-greasy and dry	Colour, odor	

due to the natural plasticisers present in beeswax, which promote a more moderate structure with a creamier feel. The addition of Kester Wax K-24 had no effect on the formula hardness, while Kester Wax K-60P and Orange Peel Wax softened the stick.

Gel study #2

In order to further understand the structuring properties of Sunflower Wax and of Beeswax, we conducted another series of experiments. We added increasing amounts of Sunflower Wax and Beeswax to three different oil mediums and recorded the resulting product hardness (by cone penetration). The oil mediums were chosen due to their different chemical identities, viscosities, and polarities. Results show Sunflower Wax provides hardness very quickly and effectively in all oils, regardless of type, while the structuring ability of Beeswax depends heavily on the medium it is dissolved in.

Textural characteristics: fine tuning formulations

Although hardness and softness are certainly textural descriptors, there are many more details to consider when describing the texture and feel of an anhydrous formulation. Some such signifiers include slip, glide, tack, deposition, uniformity, consistency on skin, after feel, uniformity, etc.

On the bench, formulators will use combinations of waxes, oils and other cosmetic ingredients to balance the properties of the formulation and achieve the texture profile and sensory characteristics desired. Table 1 provides guidance for what levels and combinations can be used to achieve different textures in anhydrous formulations.

In general, transparent fluid formulas will not require any structurants. The recommended levels for all waxes when formulating semi-solids and soft solids are very wide because of the wide range of textures possible, however, high levels of plasticiser are crucial to stable soft textures. As the hardness of the formula increases, so do the levels of structuring waxes (individually or combined), while plasticisers will need to be lowered to minimum requirements for the system.

VISCOSITY BUILDING PROPERTIES OF WAXES

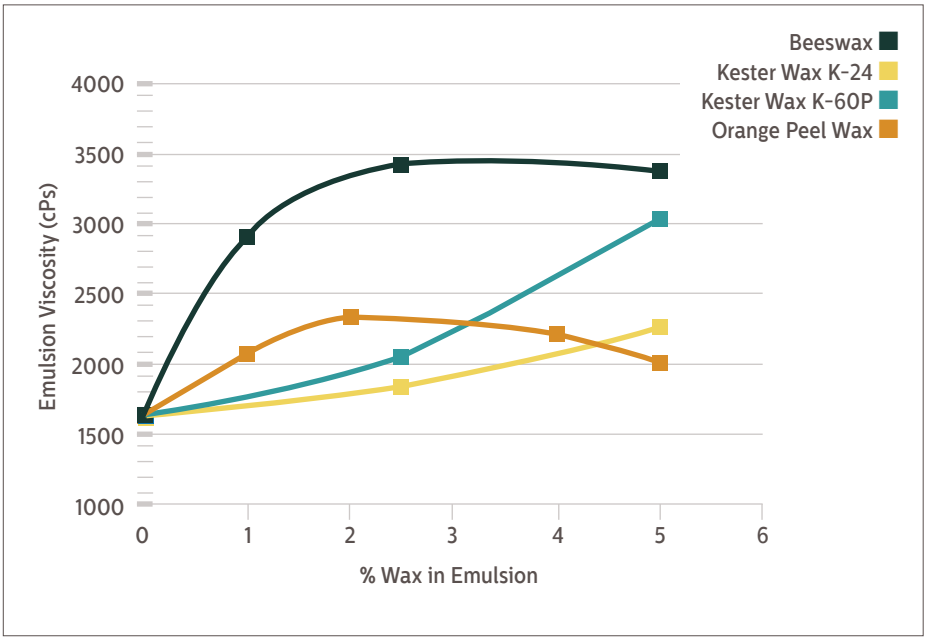

Figure 3: Viscosity building properties of waxes.

Formulating with waxes in emulsion systems

Natural waxes are lipophilic materials

Sunflower Wax and Orange Peel Wax, as well as the starting materials that make up Kester Wax K-24 and Kester Wax K-60P are biosynthesised by specialised plant cells to become the outermost boundary of the cuticular membrane (the interface between the plant and the atmosphere). The purpose is clear: waxes protect their plants from environmental stresses, while still allowing a suitable exchange with the atmosphere.[14] These natural barriers are not unlike the lipid layer that covers the surface of human skin, partially made up of triglycerides, wax esters and squalene.[15] If the human lipid layer becomes compromised, waxes can provide a temporary barrier.[16]

Due to their lipidic nature, waxes must be formulated into the oil phase of any emulsion and stabilised with a proper emulsifier. The incorporation of waxes into the oil phase can build viscosity in the emulsion, but not always

.

Natural waxes and formula viscosity

Contrary to popular belief, waxes are not interchangeable, as their compositional differences will require different emulsification techniques. For example, both Beeswax and Orange Peel Wax have relatively high free fatty acid contents, making them slightly less hydrophobic than other waxes. The presence of these free fatty acids also makes them suitable for in situ soap formations, which can then become part of the emulsifier system.

Emulsion study #1

In order to determine which of our five natural waxes build emulsion viscosity and at what rate (efficiency), Koster Keunen conducted an exhaustive series of experiments (description, design, and formulations available upon request). This evaluation looked at the impact of increasing wax concentrations in different oil-in-water emulsions and recording emulsion viscosity in each case. The data gathered was extensive, and it became clear early on that the rate at which waxes build viscosity in emulsions can vary quite a lot and depend on at least two

SENSORY PROPERTIES OF WAXES IN EMULSION SKIN CARE

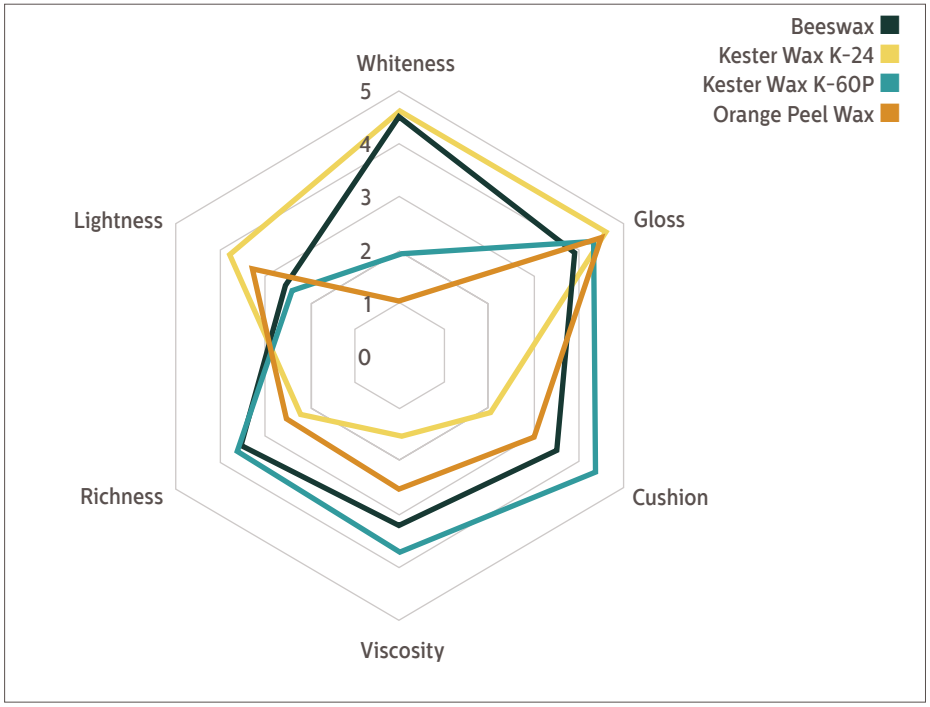

Figure 4: Sensory properties of waxes.

factors: wax chemistry and emulsion properties. Only some consistencies were observed, leaving the door open for future research. Early data does point to Beeswax as an effective thickener in most emulsions, followed by K-60P. K-24 and Orange Peel Wax had a more subtle effect, while Sunflower Wax had unpredictable effects and was eliminated from this study. Figure 3 illustrates these initial findings.

Natural waxes and emulsion feel

Waxes are very valuable as texture and sensory ingredients when formulated into emulsions, whether for skin care or certain aspects of hair care. Incorporating different waxes at different levels into emulsions will affect many product esthetics, including viscosity, pick-up, gloss, firmness, emulsion break, rub-out and after-feel, so selecting the right wax is crucial to achieving the correct sensory profile.

Emulsion study No# 2

Once more, our study proved waxes are not interchangeable. Beeswax, K-60P, K-24 and Orange Peel Wax were incorporated at 5% into the same emulsion formula, resulting in four different formulas with four very different sensory profiles (in vivo panel, n=10), as shown in Figure 4. The results show K-24 was a better choice when looking for "light and fresh" lotion esthetics, while K-60P provided richer textures and more viscous creams. The sensory profiles of both Beeswax and of Orange Peel Wax (excluding colour) fell somewhere in between.

Conclusions

A good understanding of wax chemistry is a very powerful tool for any formulator. Natural waxes are useful for chemists trying to modify existing textures or create new ones. They can also be very appealing to brands looking for 'clean' labels. This paper only highlights a handful of formulation possibilities; formulators who choose to work with waxes and learn how to use them well, will see their efforts pay off as their formulation possibilities become virtually endless.

References

1 Gerstell E, Marchessou S, Schmidt J, Spagnuolo E. (May 5, 2020). How COVID-19 is changing the world of beauty, McKinsey & Company. https://www.mckinsey.com/industries/consumer-packaged-goods/our-insights/how-covid-19-is-changing-the-world-of-beauty# (retrieved October 2020).

2 Hennigan C. (March 25, 2020). Covid-19 Increases Demand for Safe and Reliable Beauty and Personal Care Products (blog), Mintel Group Ltd. https://www.mintel.com/blog/beauty-market-news/covid-19-increases-demand-for-safe-and-reliable-bpc-products (retrieved October 2020).

3 Wright O, Blackburn E. (April 28, 2020), COVID-19: How Consumer Behavior Will be Changed, Accenture. https://www.accenture.com/us-en/insights/consumer-goods-services/coronavirus-consumer-behavior-research (retrieved November 2020).

4 Moeglin E. (October 21, 2015). Experience is All: Sense is Sensible for Today's Beauty Consumer (blog), Mintel Group, Ltd. http://www.mintel.com/blog/experience-is-all-sense-is-sensible-for-todays-beauty-consumer (retrieved November 2020).

5 Lehninger AL, et al. Final Report on the Safety Assessment of Candelilla Wax, Carnauba Wax, Japan Wax and Beeswax, J. Am. Col. Toxicol. 1984; **3**(3): 1.

6 Sethi A, Kaur T, Malhotra SK, Gambhir ML. Moisturizers: The Slippery Road, Indian J. Dermatol., 2016; **61**(3): 279–287.

7 Safety Assessment of Helianthus annuus (Sunflower)-Derived Ingredients as Used in Cosmetics, Cosmetic Ingredient Review. https://online.personalcarecouncil.org/ctfa-static/online/lists/cir-pdfs/FR708.pdf (retrieved October 2020).

8 Puleo SL. Beeswax Minor Components: A New Approach, Cosm. Toiletr., 1991; **106**(2)@ 83-89.

9 Lehninger AL, et al. Final Report on the Safety Assessment of Candelilla Wax, Carnauba Wax, Japan Wax and Beeswax, J. Am. Col. Toxicol. 1984; **3**(3): 22.

10 Fiume MM, et al. Safety Assessment of Alkyl Esters as Used in Cosmetics, *Int. J. Toxicol.*, 2015; **34**(2): 55-69S.

11 Safety Assessment of Citrus Peel-Derived Ingredients as Used in Cosmetics, Cosmetic Ingredient Review 2016; https://online.personalcarecouncil.org/ctfa-static/online/lists/cir-pdfs/FR712.pdf (retrieved October 2020).

12 Puleo SL, Rit TP. Orange Peel Wax, Cosmetics and Toiletries 1994; **109**(8):42-48.

13 Kaushik I. et al. Organogelation: It's Food Application, MOJ Food process Technol. 2017; **4**(2): 00089.

14 Christie WW. (updated September 1, 2020). Waxes, LIPID MAPS® Lipidomics Gateway. https://www.lipidmaps.org/resources/lipidweb/index.php?page=lipids/simple/waxes/index.htm (retrieved November 2020).

15 Pappas A. Epidermal surface lipids, Dermato-endocrinology 2009; **1**(2): 72-76.

16 Eberting CL, Coman G, Blickenstaff N. Repairing a Compromised Skin Barrier in Dermatitis: Leveraging the Skin's Ability to Heal Itself. J Allergy Ther 2014; 5: 187.

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