TO BEE *OR* NOT TO BEE:
Formulating with beeswax and alternatives.

KOSTER KEUNEN 1852

Belén M. Lemieux, Koster Keunen, Inc., Watertown, CT

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INTRODUCTION

Beeswax is the oldest wax known to man. It is also, along with essential oils and mineral pigments, one of the oldest cosmetic ingredients in the world. The first documented uses date as far back as 3000 BC, when ancient Chinese people used it in early nail enamels[1] and in Egypt, where it was used to stiffen and preserve wigs.[2,3]

Throughout time, beeswax has been commercially traded all over the world.[4] Supply and demand have fluctuated due to availability, environmental factors, and controversy*, yet it is still a widely-used and well-established raw material in the cosmetic industry. Beeswax is still the leading structuring agent in multiple cosmetic categories. In 2018 it was preferred over all other industry staples in lip balm and color cosmetic formulations.[5]

Perhaps the key to the perseverance of beeswax lies in its uniqueness, from both a chemical and functional perspective. Beeswax offers countless benefits, such as skin protection, natural origin, anti-microbial properties, and UV absorption.[6] It is globally approved, biodegradable, non-toxic[7], non-irritant, and non-comedogenic.[8]

In this article, we will review beeswax as a functional raw material and how to best use it in cosmetic formulations. Furthermore, we will provide options for those who wish to remove it.

FORMULATING WITH BEESWAX

At Koster Keunen, we believe every cosmetic chemist can benefit from knowing the basics of formulating with beeswax. From a formulation standpoint, it is mainly a viscosity builder with many added benefits. Because of its lipidic nature, its main cosmetic function is to provide a protective skin barrier (and moisturize by occlusion). While many other raw materials provide these benefits, beeswax has a unique chemistry that makes it multifunctional.

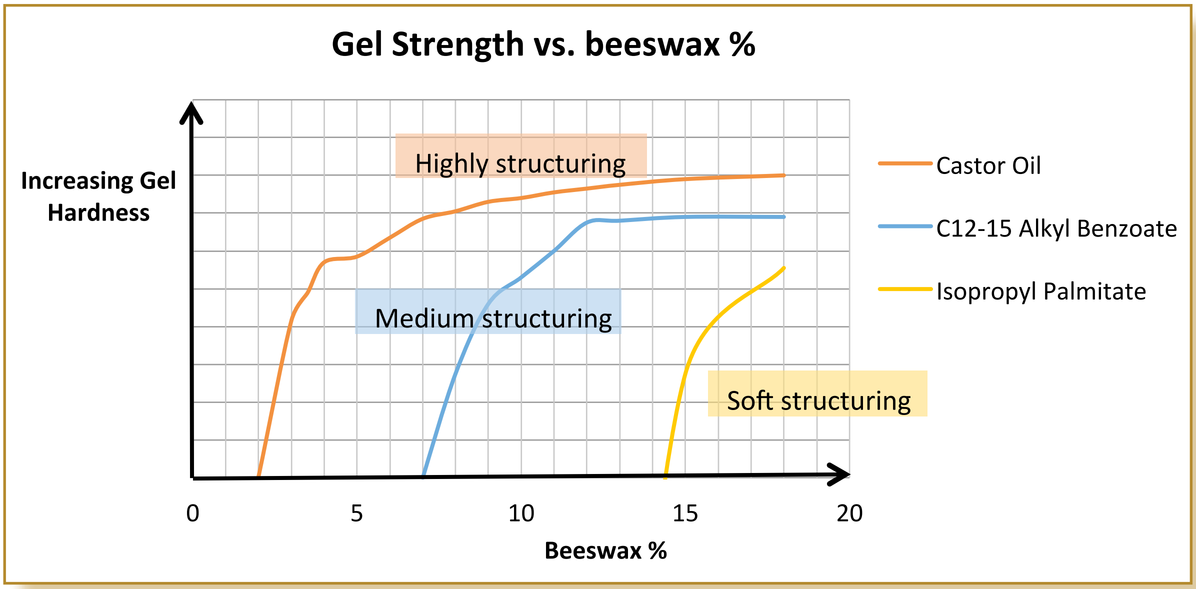
Beeswax is biosynthesized by the European honey bee (*Apis Mellifera*) in response to specific stimuli . The process begins in the abdominal glands and epidermal cells of worker bees, where virgin beeswax is first secreted. It is then, along with propolis (collected from trees, shrubs, and flowers surrounding the hive), mixed and chewed by the bee, where it is chemically modified by salivary enzymes , rendering the mix ready for use as comb wax, with the main purposes of supply storage and brood protection . Like other natural waxes, beeswax is a complex mixture of organic compounds, mainly long chain esters, hydrocarbons and fatty acids , but its polyesters, polycosanols, and minor components make it unique. The table below outlines the chemical composition of beeswax and how each component can relate to function (Puleo, S., personal communication, March 2018).

*Koster Keunen's position on beeswax is that it is a "cruelty-free" product. Worldwide, bees must be kept in optimal conditions in order to thrive and be productive. It is not in beekeepers' best interest to harm their bees, as bee product trade and pollination are part of their livelihood. In developing areas of the world, entire villages depend on the income from honey and beeswax trade. (Koster, J., personal communication, December 2017).

Chemical Functionality	Approximate %	Chain Length	Cosmetic Function
Esters	45 to 50%	C40 - C52	Gelling, Structuring
Polyesters	15 to 20%	C54 – C68	Plasticizing
Hydrocarbons	15 to 18%	C21 - C35	Hydrophobicity
Free Fatty Acids	10 to 15%	C16-OH – C24 – C30	Gelling, Reactivity
Free Fatty Alcohols	1 to 2%	C24 – C32	Potential Biological Activity
Minor Components	2 to 5%		Anti-Oxidants

Table 1. Chemical composition of beeswax and how it relates to function

In anhydrous systems, beeswax thickens and structures oils by forming stable gel networks where gel viscosity and hardness are proportional to the percentage of wax, but also depend on oil/wax compatibility, as is shown in Figure 1. In realistic terms, by manipulating very few variables, cosmetic products will run the gamut of textures, from waxy hard sticks to soft sticky balms.



But beeswax doesn't just provide structure, its uniqueness lies in its dual functionality as both a structuring agent *and* a plasticizer, which is important for stick integrity, smooth textures, and even color deposition. The plasticizing properties in beeswax will also help prevent crystallization, "sweating", and bloom. This double functionality also simplifies the formulation process.

The table below is intended to provide a formula "backbone" for anhydrous products.

Raw Material Type	Approximate %	Cosmetic Function
Beeswax	5 – 10 %	Structuring, Plasticizing, Film forming, etc.
"Oil trio"*	QS	Emolliency, spreading, gel modification
High melt point wax	3 - 8 %	For high temperature stability needs OR increasing stick hardness
Plasticizer	0 - 7 %	Promotes system compatibility, works synergistically with beeswax
Fillers / Pigments	5 – 10 %	If applicable

Table 2. Anhydrous formulation guide.

The variation in % will be determined by the final formula application. In simple sticks the first three rows will usually suffice, but for softer (squeezable/scoopable) balms, an added plasticizer, such as *Kester Wax K-60P*, will work synergistically with beeswax to keep the formula thermally stable and aesthetically pleasing (see Sample Formula 1).

Beeswax also has widespread use as a thickener in emulsion formulas (both oil-in-water and water-in-oil), especially where a thick consistency is desired, such as mascaras, body butters or cold creams.

In oil-in-water emulsions it behaves like a typical oil/wax phase component: with the right emulsifier/stabilizer system, it will thicken emulsions via internal phase packing. There are a few considerations formulators should be aware of: because of the free fatty acids present in beeswax, the emulsion pH will be affected. If the amount of beeswax in the formula is high (generally above 5%), the pH will be measurably lower; this can be avoided by adding a calculated amount of alkali to the water phase. In this scenario the free fatty acids will be saponified in *situ*, gradually turning the beeswax from oil phase component to co-emulsifier, and thus changing the properties and texture of the emulsion. In our lab in Watertown, CT, we have even found that different degrees of beeswax saponification can lead to different textures and viscosities. As a side note, cosmetic chemists should be aware that the newly formed in situ soaps will impart an anionic character to the emulsion, and the remaining formula ingredients should be selected accordingly.

The table below is intended to provide a formula "backbone" for oil-in-water emulsions.

Raw Material Type	Approximate %	Cosmetic Function
Water Phase	QS	Carrier, solvent for humectant, preservative, gum/other thickener, chelating agent, pH adjustor, etc.
Emulsifier System	3 – 5 %	Emulsifier
Oil Phase (2 – 8 % beeswax, other oils, esters, silicones)	10 – 30 %	Moisturization, film formation, viscosity building
"Cool down" phase	1 – 10 %	If applicable (fragrance, volatiles, heat sensitive actives, etc.)

Table 3. Emulsion formulation guide.

*A common approach to oil/emollient selection in anhydrous formulations is to start with three oils with different sensorial profiles, such as heavy/slightly draggy plus medium/velvety plus light/satin/volatile.

Water-in-oil emulsions are not as common in cosmetic preparations, but their resistance to wash-off and their occlusive nature make them ideal for certain applications, such as sunscreens, or topical ointments for skin disorders, and beeswax plays an important role. Beeswax is incorporated into the external/oil phase by melting and mixing it with the remaining oils in the formula - generally combinations of mineral oil, petroleum waxes, vegetable oils, and squalene - and a suitable water-in-oil emulsifier . A well-known subcategory is the traditional "cold cream", a water-in-oil emulsion based on the in situ soap formation between the beeswax acids and a suitable base, which is added to the internal/water phase prior to mixing. As always, beeswax is incorporated into the oil phase, but in these systems, it functions as the primary emulsifier. Modern cold cream cleansers use triethanolamine (replacing borax) as the base for soap formation, and many will add co-emulsifiers, like Permulgin D (see sample formula 2).

SAMPLE FORMULAS

Natural Squeezable Tinted Lip Balm	
Ingredient Name	***%***
(Phase A)	
Beeswax	6.0
Helianthus Annuus (Sunflower) Seed Wax	3.0
Polyhydroxystearic Acid (Kester Wax K-60P)	12.0
Lauryl Laurate (Kester Wax K-24)	12.0
Cocos Nucifera (Coconut) Oil	39.6
Ricinus Communis (Castor) Seed Oil	18.9
Tocopheryl Acetate	1.0
(Color Concentrate)	
Ricinus Communis (Castor) Seed Oil	7.24
Choice Colorant	0.26
Procedure: Combine Phase B ingredients and mill until homogeneous. Combine Phase A ingredients in a vessel. Heat to 80-85 °C and mix until uniform. Once homogenous, add Phase B to Phase A and mix. Cool to RT with mixing and pump into tubes.	

Sample Formula 1. Soft anhydrous product.

Traditional Cold Cream	
Ingredient Name	***%***
(Phase A)	
Beeswax	7.0
Ceresin	12.0
Cetearyl Alcohol, Ceteareth-20 (Permulgin D)	1.0
Behenic Acid	2.0
Mineral Oil	35.0
Carbomer	0.05
(Phase B)	
Aqua	41.7
Triethanolamine	0.75
DMDM Hydantoin	0.5
Procedure: Begin heating water to 75 °C and add Phase B ingredients one at a time, mixing until uniform. Heat waxes in Phase A to 75 – 80 °C, until melted, add Carbomer and disperse well. Slowly add Phase A to Phase B with moderate mixing until emulsion is smooth. Cool slowly at low speed to approximately 55 °C and pour into containers.	

Sample Formula 2. Cold cream water-in-oil emulsion.

FORMULATING WITHOUT BEESWAX

There are two main reasons product developers might shy away from beeswax: cost reduction and the desire to remove animal byproducts. As our markets and customers evolve, so do we. Koster Keunen can assist in developing personal care products without beeswax or in phasing it out of existing formulas. Due to the complexity of beeswax, science has yet to reproduce it perfectly and, as of today, there is no one perfect "drop-in" for all applications. But, as experts in beeswax, we welcome the challenge and can offer numerous choices.

Synthetic replacements are cost effective, efficient blends of commercially available waxes engineered to closely match the properties of natural beeswax. As an added benefit, these alternatives carry the ambiguous INCI nomenclature of Synthetic Beeswax, making it difficult for competitors to reverse engineer finished products that contain it. In formulations with small percentages of beeswax they are usually a one-to-one replacement, but formulas with large amounts may require some rework, which our technical team can assist with.

It is possible to replace beeswax with natural alternatives, although the more limited can make it challenging. Koster Keunen encourages product developers with natural and vegan requirements to contact us when looking to replace beeswax (see sample formula 3). The percentage of beeswax, its functionality and the type of formula all play important roles in a successful substitution. The following chart is provided as a guideline.

Replacing Beeswax in All Formulation Types

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	ANHYDROUS	
	Beeswax as primary structurant	Beeswax is not primary structurant
	Use % as an indicator	Use % as an indicator
Formulation Guide	Formulators must use a combination of a structuring wax + plasticizing wax. This replacement will require some engineering* with other ingredients in system.	Direct replacements are possible and available. Koster Keunen has many options*, a few key choices are listed below.
Starting Use %	**75/25 ratio of below : 1 beeswax**	**1:1 beeswax**
Option #1 No restrictions	Synthetic Beeswax 122 / Kester K-82P Synthetic Wax /Kester K-82P	Synthetic Beeswax 122 Microcrystalline Wax
Option #2 Natural/ Naturally Derived	Candelilla Wax / Kester K-60P Kester K-72 / Kester K-60P	Kester Wax K-72 Kester Wax K-62 Kester Wax BWR
Product Types	Balms, anhydrous ointments, jellies, low viscosity color cosmetics	Lip balms, lipsticks, pencils.

***Contact Koster Keunen with any questions or for assistance.**

Vegan Creamy Mascara	
Ingredient Name	***%***
(Phase A)	
Aqua	44.9
Glycerin	3.0
Hydrolyzed Quinoa	1.0
Cellulose	1.0
Dehydroxanthan Gum	0.3
Potassium Hydroxide	0.3
(Phase B)	
Kester Wax K-BWR	**6.0**
Oryza Sativa (Rice) Bran Wax	**5.0**
Polyhydroxystearic Acid (Kester Wax K-60P)	**2.0**
Behenyl Alcohol, Polyglyceryl-3 Stearate (Kostol PGP)	**2.5**
Stearic Acid	**2.0**
Caprylic/Capric Triglyceride	6.0
Iron Oxides CI 77499	12.0

Vegan Creamy Mascara (Cont.)	
Ingredient Name	***%***
(Phase C)	
Alcohol Denat.	5.0
Phenoxyethanol, Caprylyl Glycol	1.0
Carnauba Milk (Paraben Free)	**8.0**

Procedure: Combine Phase A ingredients and heat to 85°C with mixing. Melt and mix Phase B materials, except for the pigment. Once the materials are melted, slowly add the pigment under agitation. Continue to mix, while maintaining a temperature of 85°C. Once both phases reach temperature, add Phase B to Phase A. Mix, then cool until 50°C and add Phase C ingredients, one at a time mixing after each addition. Cool to RT and pump into containers.

Sample Formula 3. Vegan oil-in-water emulsion.

EMULSIONS

Water-in-oil Formulations	Oil-in-Water Formulations	
	Beeswax ≥ 5%:	Beeswax ≤ 2%:
Mimicing functionality is key to replacing beeswax in these systems. For insitu soap systems, a thickener & emulsifier combination is needed*. As a thickening agent, direct replacements available.	Direct replacements are possible. They requires engineering* , including HLB matching and pH adjustments. This is the most challenging replacement.	Direct replacements are possible and relatively easy.
1:1 beeswax	**1:1 beeswax**	**1:1 beeswax**
Synthetic waxes*	Kester Wax BK-40 Synthetic Beeswax 122	Kester Wax CT Kester Wax BK-40
Kester Wax BWR	Kester Wax K-72 NaturalAtum	Kester Wax BWR Bayberry Wax Kester Wax K-60P
Cold creams, ointments, sunscreens	Body butters, creams, hair styling, waxes, pomades, mascaras	Lotions, creams, hair styling, waxes, pomades, mascara

CONCLUSIONS

Much like honey bees, formulation chemists must also adhere to strict rules, prioritize projects accordingly, and be able to change strategies quickly based on outside challenges or more pressing goals. At Koster Keunen, we believe an understanding of the chemistry of beeswax and how to utilize this versatile raw material in formulations are important tools for a formulator. We also have the expertise and the technology to assist our customers in many other areas, such as wax chemistry and applications, replacements and modifications, troubleshooting, and innovation.

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1021 Echo Lake Road, Watertown CT 06795

+1-860-945-3333 • Info@kosterkeunen.com • www.kosterkeunen.com