

Grapefruit: the 'Forbidden' Fruit

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The most recent addition to the citrus family, the grapefruit was relatively unknown to both Eastern and Western civilizations until its discovery in Barbados in 1750. Since then, it has spread to tropical and sub-tropical regions throughout the Western Hemisphere, and is renowned for its distinctive, sweet-sour flavor. Here, the authors review the similarities between the grapefruit and its larger ancestor, the pummelo, and examine grapefruit oil components and their distinct flavor profiles.

What's in a Name?

The moniker 'grapefruit' has led a precarious existence — perhaps a reflection of the very fruit it describes. It is generally thought that in 1750, Griffith Hughes recorded the first ever description of the grapefruit — calling it the 'forbidden fruit.' The less exotic description, grapefruit, surfaced in 1814 when botanist John Lunan in his work, *Hortus Jamaicensis*, commented that the fruit was a smaller variety of the pummelo, also known as the shaddock, and should be named after its similarity in flavor to the grape.

As the term grapefruit became more commonly used, horticulturists found it misleading and began an attempt to drop the name in favor of 'pomelo.' This only added to the confusion due to the likeness of the grapefruit and the pummelo itself.

In 1962, in an attempt to spice up interest in the fruit, the Florida Citrus Mutual proposed yet another name change. However, no suitable candidate was found and public outcry prevailed, so the grapefruit kept its name.

Pummelo or Grapefruit?

Today's grapefruit may in fact be an accidental hybridization between the pummelo and the orange, combining the sweet flavor of the orange with the tangy



The grapefruit is comprised in part of genetic material from its older descendant, the pummelo.

Photo credit: Treatt plc

notes of the pummelo. But what are the differences between the pummelo and the grapefruit?

Pummelo: Originally from Malaysia and widely distributed throughout Southeast Asia, the pummelo, *Citrus grandis*, is the most stable of all citrus varieties in storage, to the point of being sold year round. The pummelo is older and larger than the grapefruit and

has an average weight of 1-3 lb. The fruit has more structured juice vesicles than the grapefruit, which can be eaten apart from the fruit segment, and its open central core has around 16 to 18 segments. With a thick peel and white pith, its flesh is sweeter and somewhat chewier than the grapefruit, and shows great variation in flavor.

Grapefruit: The thinner-skinned grapefruit, *Citrus paradisi*, contains around 12 segments and is commonly found with skin defects, such as discoloration, scars and thorn scratches. Early Florida grapefruit were of the seedy 'Duncan' variety. Its excellent flavor profile makes it the preferred type for juice production, and by extension, a significant contributor to the essential oil market. A second, smaller variety of white grapefruit, the 'Marsh,' was developed in Florida in the late 1800s. Containing fewer seeds, this was first promoted in 1886 as the 'Marsh Seedless.' It then became the leading grapefruit cultivar worldwide and remains so.

In addition, there are many pink grapefruit varieties, ranging from slightly rosy in color to deep red. The fruit can show pigmentation in the peel, flesh or both. Its pink color is derived from the carotenoid lycopene, which usually peaks early in the harvesting season and fades late. Some of the most intensely pigmented types include the Star Ruby, Flame, Rio Red, Ray Ruby and the Henderson.

Since the 1980s, demand for white and pink grapefruit has declined rapidly with both the fruit and juice competing in an increasingly crowded fresh produce marketplace. Decline in demand for pink varieties has been less dramatic, primarily because consumers remain attracted to their sweeter flavor profile. Pink grapefruit

“[T]he outlook for the grapefruit market is as unpredictable as the price of its products.”



Photo credit: Treatt pic.

The pummelo is larger than its successor, the grapefruit, and possesses a sweeter and chewier flesh.

juice consumption has actually increased, although this has not been significant enough to offset overall reductions in demand for pink grapefruit.

Growing and Harvesting

Grapefruit need prolonged periods of heat to prosper, and so grow well in subtropical regions in the United States, Israel, Mexico, South Africa and Cuba. The top grapefruit-producing country is the United States, contributing over 60 percent (an estimated 3.8 metric tonnes) of fresh grapefruit production worldwide. Within the United States, the Florida citrus belt accounts for around 75 percent of all grapefruit-bearing acreage. The localized nature of the grapefruit regions does, however, dictate a vulnerability to severe weather conditions.

Ongoing Issues: In 1983, a devastating freeze almost destroyed the Texas crop, wiping out around 70 percent of that year's harvest, reducing it to almost nothing in 1984. Similarly, the Florida freezes of the late 1980s severely curtailed production. In 2001, Hurricane Michelle ploughed through Cuba, destroying 80 percent of the crop.

It is not only the weather that affects grapefruit crops. Many citrus trees are prone to disease and grapefruit is no exception. The presence of the citrus tristeza virus, coupled with the infestation of the brown citrus aphid, could threaten many of the grapefruit trees on orange rootstock. If these trees were killed, their replacement would depend entirely on economic conditions at that time.

Grapefruit harvesting and processing decisions are determined by the price of fresh grapefruit. An ongoing decline in Florida harvest volumes is predicted as the number of trees continues to fall. For example, in Florida, the number of grapefruit trees has fallen by approximately 25 percent since 1996. The price and availability of grapefruit oil and essence oil is strongly influenced by seasonal periods of over- and under-supply and, at present, remains particularly volatile. The longer-term outlook is harder to predict.

Grapefruit Oils

There are two types of grapefruit oil: cold pressed and essence. The former is recovered, without the use of heat, from the peel of grapefruits destined for juice production, and has a unique organoleptic profile. The latter, a by-product of the concentration of grapefruit juice, offers an outstanding 'juicy' grapefruit flavor profile.

During the evaporation process, which transforms grapefruit juice into grapefruit juice concentrate, the volatile flavor fraction is recovered and re-condensed in a similar process to orange essence oil manufacture. The aqueous distillate is chilled and allowed to separate, and the thin layer, which forms at the top, is decanted as grapefruit essence oil. This relatively colorless oil is different in character to peel oil, but they can be used effectively together to provide a balanced grapefruit flavor.

Cold pressed peel oil analysis: The chemical composition of grapefruit peel oil is similar to orange oil — not surprising considering the fruit's parentage. The complex structure of grapefruit peel oil means it is one of the most difficult citrus fruits to quantify analytically. While dextro-limonene contributes to the organoleptic profile, most of the active flavor compounds are found in the less prevalent chemical groups: aldehydes, ketones, alcohols and esters.

Early research identified nootkatone — a component reported to increase in concentration as the fruit matures on the tree — as being primarily responsible for the characteristic grapefruit peel oil flavor. However, nootkatone may be as much a quality 'marker' as an actual direct flavor contributor. Easily determined by gas chromatography, it remained the benchmark for grapefruit peel oil quality for many years.

Subsequent research has shed more light on the qualities of grapefruit oil, establishing that other components appear to contribute more significantly to the flavor of grapefruit peel oil. One class of compounds, terpene thiols, tends to bind strongly to olfactory receptors and has a major organoleptic impact. The compound 1-para-menthene-8-thiol has been shown to impart strong grapefruit-like characteristics and has an aroma threshold of 1 ppb in water — one of the lowest of any substance on record. The aldehydes (primarily octanal and decanal), plus β -

“[G]rapefruit...combin[es] the sweet flavor of...orange with the tangy notes of the pummelo...”

caryophyllene, which is known for its 'woody' aroma, contribute significantly to the overall flavor profile. Notable levels of β -caryophyllene are found in grapefruit peel oil, with α -humulene, germacrene and dextro-cadinene also present.

Although most essential oils exhibit an organoleptic profile more dependent on a matrix of odor active substances than any particular key component, grapefruit appears to be one of the least quantifiable by strictly analytical means. There are many factors to take into consideration to fully evaluate the quality of grapefruit peel oil. These include organoleptic evaluation to measure the terpene thiol contributions, as well as the overall profile.

Essence oil: Different in character from peel oil, grapefruit essence oil quality varies significantly depending on the supplier and its processing methods. High quality essence oil has a fruity top note and a light, sulfurous grapefruit profile. As with grapefruit cold pressed oil, the traditional quality marker for grapefruit essence oil is the level of nootkatone present, but again, nootkatone should not be taken as the sole quality determinant. Ethyl butyrate, methyl butyrate and acetaldehyde are all-important contributors to the 'fresh juice' note desirable in high quality grapefruit essence oil.

Summary

The waning popularity of fresh grapefruit and its juice, coupled with the declining number of trees due to disease and changing climatic conditions, means the outlook for the grapefruit market is as unpredictable as the price of its products. However, the unique, sulfury and bittersweet profile of the grapefruit should continue to stimulate demand amongst food and beverage manufacturers seeking a distinct flavor to enliven products and provide some of the unique characteristics of the 'forbidden' fruit. ■

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