

Flavoring with Citrus Oils

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Citrus flavors are popular in beverages as well as all other sweet products such as confectionery, cookies and desserts. Lately, we also see a growing popularity in food, particularly in sauces and dressings. The level of use varies widely, from about 200 ppm in beverages to more than ten times higher in chewing gum (see Table I). This is related mainly to flavor release because of the particular food system.

Soft Drinks

Although the level of flavor in soft drinks is the lowest on this list, the total consumption volume is by far the highest. It is no surprise then that the beverage industry is the largest user of citrus oils for flavoring; therefore I will discuss it first.

Let us begin by taking a look at the industry itself (see Table II). The world produces a total of about 17 billion cases of 24 x 8-ounce bottles, 40% consumed in the U.S. Cola drinks constitute about 50% of the world soft drink production.

The main flavors used in soft drinks are cola, lemon-lime, and orange, all which are based on citrus oils, and constitute about 80% of all soft drinks in the world (see Table III). The colas are the main segment in the U.S., but in international markets orange and other flavors are far more important.

Another quite significant difference is the per-capita consumption, which is by far the highest in the U.S. In fact, it is ten times higher than average for the rest of the world (see Table IV). These figures are based on 1985 data, and it is amazing that the U.S. consumption has climbed even higher in 1986 to 46 gallons, or 175 liters per person. We expect this trend to continue at 2-3% per year in the U.S., and about 3-5% in international markets.

I have estimated the use of citrus oils in soft drinks as shown in Table V. The total worldwide consumption, based on a weighted average use level, amounts to 7,500 metric tons of oils for 96

Table I. Citrus Oils in Food and Beverages

U.S.A. Average Maximum Use Level in PPM*

	<u>Beverages</u>	<u>Ice Cream</u>	<u>Confect.</u>	<u>Baked Goods</u>	<u>Dessert</u>	<u>Chewing Gum</u>
Grapefruit	160	180	630	370	250	1,500
Lemon	230	380	1,100	580	340	1,900
Lime	130	160	680	370	200	3,100
Mandarin	62	160	350	190	30	83
Orange	210	330	1,000	430	1,300	4,200

*Source: 1965 FEMA Report on GRAS Substances

Table II. 1985 World Soft Drink Composition

	Mill. 8 oz. cs.	%
World Total Soft Drink Industry	17,000	100
Int'l Soft Drink Industry	10,000	59
U.S. Total Soft Drink Industry	7,000	41
World Cola Industry	8,500	100
Int'l Cola Industry	4,100	48
U.S. Cola Industry	4,400	52
World Flavor Industry	8,500	100
Int'l Flavor Industry	6,000	70
U.S. Flavor Industry	2,500	30

Table III. 1985 Major Soft Drink Flavors International vs. USA

	International %	USA %
Colas	41	63
Lemon-Lime	15	14
Orange	17	6
Others	27	17

Table IV. Soft Drink Consumption Liters Per Capita

Country	%
USA	172.4
Mexico	107.3
Canada	84.9
West Germany	65.5
Venezuela	60.5
Netherlands	58.5
Spain	53.9
Saudi Arabia	49.2
United Kingdom	48.0
Italy	32.6
Average International	16.7

Table V. Citrus Oils in Soft Drinks

	Cola ^a		Lemon-Lime		Orange		Other		Total	
	Bev. ^a	Oil ^b	Bev.	Oil	Bev.	Oil	Bev.	Oil	Bev.	Oil
USA	26.1	1040	4.2	850	2.0	400	5.4	250	37.7	2540
International	24.0	960	9.1	1350	9.6	1900	15.3	750	58.0	4960
World	50.1	2000	13.3	2200	11.6	2300	20.7	1000	95.7	7500

^a Beverage volume in liters x 10⁹^b Citrus oils in metric tons

billion liters of beverage. One third of the oils is consumed in the U.S., and that usage is about equally divided over the main flavors: cola, lemon-lime and orange.

Soft drink flavors utilize citrus oils in various ways for technological reasons, mainly based on solubility in water. Cloudy beverages use citrus oils as such because the terpenes provide part of the cloudy appearance.

In clear drinks such as lemonades, we typically use extracts which remove most of the terpenes. Concentrated and terpeneless oils are used for the same reasons, as well as for flavor effect or stability. We also use peel distillates, flower absolutes, and in fact, any other form to produce special effects or minor flavor notes.

The performance of citrus oils in soft drinks is quite different from most other food applications, because we employ low levels of oil in water at pH 3 or less, and this leads to many reactions which affect flavor quality. The cyclization of citral, and the hydration of terpenes is well known under these conditions. The flavor changes in a lemon-lime beverage are quite significant even in a few weeks. The loss of citral is quite dramatic, and has a very noticeable effect on overall flavor character and strength.

These types of changes are typical for soft drinks and, in general, are not found in other food or fragrance applications, or they occur at a much lower rate. This means that quality considerations for the soft drink category should be quite different, too.

Confectionery

The next largest user of citrus flavors is the confectionery industry. Here orange, lemon and lime are the most popular flavors in certain categories, and to a large extent, these flavors are, indeed, based on citrus oils. It is far more difficult to develop reliable usage information in this case, because there are few statistics on production, and none on flavors.

It is interesting that the U.S. consumption is

Table VI. Confectionery Production by Country - Million Tons

	1984	1985
France	0.40	0.40
Italy	0.20	0.21
UK	0.73	0.74
USA	2.03	2.17
West Germany	0.78	0.75
Total	4.12	4.27
U.S. KG per capita	8.60	9.10

Table VII. Confectionery Flavoring

Chocolate	60%
Other	40%
Citrus Flavored	20% Est.
Europe/USA Citrus Candy	800 x 10 ⁶ KG
Citrus Oils at 0.1%	800 tons
World Usage Estimated	> 1,000 tons

the highest in the world, and is still climbing (see Table VI). I estimate that 20% of confectionery is citrus flavored based on hard candy or boiled sweets. If the flavor distribution is the same for the world as for the U.S., the world consumption of citrus oils in confectionery probably exceeds 1,000 metric tons (see Table VII).

Most of this would, indeed, be citrus oils as such, but also concentrated and terpeneless oils. I also recognize that in some instances, cheaper versions may be used, such as combinations with artificial ingredients.

Other Applications

There are many other applications besides soft drinks and confectionery, but these are all much smaller in usage, and there are no good statistics. Examples are ice cream, cookies, desserts, powdered drinks, alcoholic beverages, food, etc. In some of these, citrus flavors are popular, such as desserts, but in others, such as ice cream and cookies, other flavors such as vanilla and chocolate are far more important.

In other words, it is virtually impossible to obtain a reasonable estimate of how much citrus is used in these categories. A conservative estimate is 500 tons, which would make the total usage of citrus oils for flavoring at least 9,000 tons. This is a major portion of the world production of citrus oils, certainly as far as lemon and lime oils are concerned. Based on production figures that I have heard today, or seen before, at least 60-70% of all citrus oils are used in our industry, which represents about 20% of the world's essential oil industry which is estimated at 50,000 tons.

Trends

Now that we have seen the extreme importance of citrus oils to the world of flavor, I will focus on trends for the future. From the user's perspective, the following factors are most important in predicting the future.

Consumption—It is quite clear that consumption of food and beverages will grow not only as a function of population growth, but also on a per capita basis. We have seen that soft drink consumption in the U.S. is ten times higher than in the rest of the world. This provides an enormous potential for growth in the largest user category. Our forecasters believe that a compound annual growth rate of 3-5% for the next five years is reasonable.

This would increase the world production of soft drinks to at least 20 billion cases per year, and citrus oil consumption would increase by 1,500 tons in 1992. I am sure that similar trends hold true for other food categories, and it seems to me that a healthy increase in citrus oil consumption may be expected.

Natural vs. Artificial—Another factor that drives in the same direction, is the trend toward natural flavors. This is a strong trend in the U.S. and Europe, and we expect it to continue.

Natural flavors are not safer than artificial ones, but marketers have convinced the consumer that they are better. In my opinion, this is often true, mainly because of the complexity of natural flavors. Citrus oils are used widely not only because lemon, orange, etc., are popular flavors, but also because they often can be used for other natural flavors. This trend not only increases the consumption of citrus oils, but also will put greater demands on purity, to make absolutely sure that the oils are, indeed, completely natural.

Performance—This leads me straight into the next trend, or the growing demand for performance, and a subpart of that purity. The main concern, however, is to be able to find high quality citrus oils with good flavor stability, particularly for soft drinks. I addressed this point at the previous IFEAT meeting in Bulgaria, and believe that it is a very important one. As I have

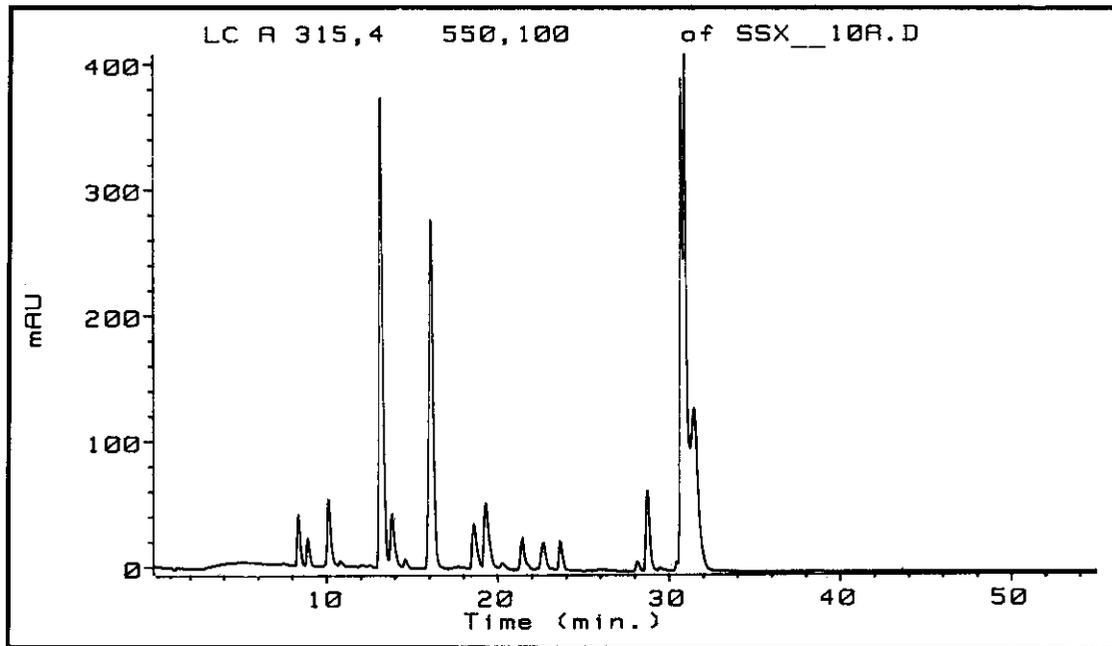


Figure 1. Genuine Lemon Oil

shown, we lose citral very fast in soft drinks and, therefore, we rely heavily on the other oxygenated compounds, which react much more slowly. For this reason, we at Pepsico, taste our oils not only fresh, but also after aging in beverage. We are, in fact, selecting oils mainly on performance criteria, and it would be to our mutual advantage if oils could be grown, processed, and selected for greater stability. With the recent advances in science, particularly biotechnology, analytical chemistry, etc., it seems to me that such a course is feasible.

We certainly have made use of the advances in instrumental technology, and a very detailed, routine, compositional analysis of citrus oils is now standard. The gas chromatograph now has capillary columns, and sophisticated electronics to handle the data, which allows us to look into much more detail than before. Multi-dimensional GC's expand that capability even further. The detectors have improved, too, and we now routinely use the ion-trap as well as mass sensitive detector to identify components, or look for a specific component in the selective ion monitoring mode.

In addition, we use the GC-Mass Spectrometer for research and special investigations. Similar progress has been made in the liquid chromatographs which we use to look into the non-volatile components of citrus oils. Dr. McHale described at last year's international essential oil meeting,

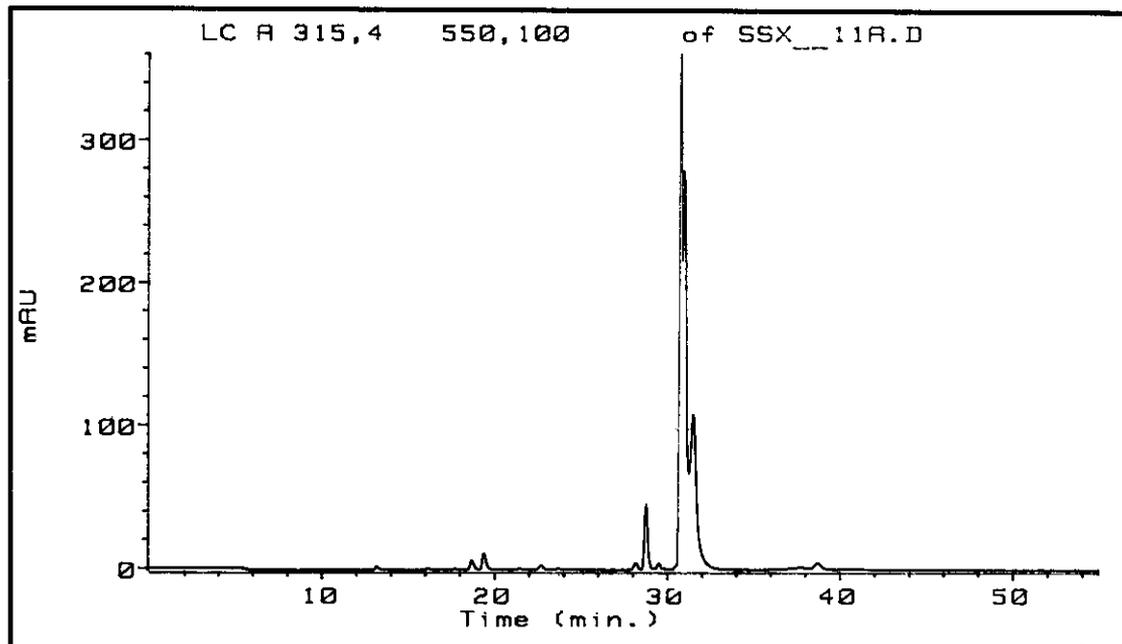


Figure 2. Washed Lemon Oil

the elegant work done at Schweppes through identification of the coumarins and psoralens.

Typically we look at patterns, and these can be very useful in identifying origin or to detect the presence of a washed oil, for instance, due to a significant decrease in coumarins as a result of the extraction procedure.

I brought some examples of 3-dimensional liquid chromatograms. Figure 1 is a genuine lemon oil with the coumarins shown in the left region. Figure 2 is a washed oil, and as you can see, the psoralens are left, but the coumarins are almost completely extracted.

Most of this work is done to make sure that oils are, indeed, genuine. Similar research has been done in Italy for many years.

My point is that we probably know as much as there is to know about the composition of citrus oils, but now we need to take the next step to correlate composition to performance. Ultimately, we need to grow and process for better quality. We also need to make sure that those customers who demand genuine oils, indeed, get them.

Mergers—This leads to my final point on trends, what we call merger mania in the U.S. It is clear that food and beverage companies are being concentrated into larger and larger corporations.

As a result, we can expect not only more demanding purchasing criteria, but also tighter quality requirements and more concern for per-

formance, naturalness, and lack of contaminants such as pesticides, etc. In addition, world demand will grow significantly, as discussed earlier.

All this puts pressure on the citrus industry to produce more and better quality oils as efficiently as possible.

Conclusion

Hopefully I have shown that citrus oils are extremely important for the flavoring of foods and beverages and that their consumption is growing steadily at more than 3% per year. On the other hand, the demands for performance can be expected to become more strict, particularly as far as stability and purity are concerned.

The future looks bright for citrus oils regarding flavoring. Now we must concentrate on working together to achieve better quality products for our mutual benefit.

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