

Lemon Essential Oil: World Production, Extraction Methods and Trading^a

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Lemon is one of today's most extensively cultivated citrus fruits worldwide, after the orange. Its native home is unclear, though it is likely of Indo-Burmese origin. This fruit reached Europe via Persia and the Middle East sometime during the 12th Century, expanding further during the Arab Empire in the Mediterranean areas. Later, Christian crusaders contributed to its expansion as well.

Christopher Columbus carried seeds to the West Indies (Americas) in the 15th Century. He was followed by the Catholic missionaries who spread throughout South America. They were responsible for the introduction of lemon to California in the 18th Century.

Sicilian lemon oil was first mentioned in 1780, when Abbot Domenico Sestini described, with technical details, extraction processing by means of "sponge."

The word "lemon" originates from the Arab, "laimun" and Persian "limum." It belongs to the rutaceae family and is named botanically, *Citrus limon* (L.) Burm. There are numerous identified cultivars available commercially, many of which have been introduced in quite a number of countries worldwide.

Although lemons grow well under tropical and semi-tropical climatic conditions, world production is mainly restricted to sub-tropical areas. In some conditions, lemons will bloom once a year, but a series of flowering flushes may occur throughout the seasons. A particular flowering has been obtained when fruit crop appears scarce. The best example of this is represented by "Verdelli" lemons, usually found in August. If tree irrigation is withheld during June, a flowering can be induced after irrigation and fertilizers follow the wilting period. This practice called *forzatura*, and was first adopted by Sicilian growers at the beginning of the 19th Century.

The Lemon Fruit

I will begin my overview with Italy. Ninety percent of this country's crop is located in the Island of Sicily. The *femminello comune*, or *primofiore* type, includes a group of various selections, each of which has its own character-

istics, and accounts for the largest percentage (75%) of total lemon fruit produced. This may include crops named:

- *Primofiore*, harvested from September through April (winter).
- *Bianchetti*, harvested from February through May (spring).
- *Verdelli*, harvested from May through September (summer).

The harvest is principally determined by varying climatic conditions and other factors, depending on the *femminello* selections. It is mainly from these that essential oils are being extracted. Other lemon-crop varieties worth mentioning are:

- *Interdonato*, or *speciale*, noted for its early ripening. It originated in Nizza, Sicily, in 1875 on Colonel Interdonato's farm. Of this group, *monachello* displays an outstanding resistance to *Malsecco* disease.
- In Spain, the *primafiore* cultivar, also named *fino* (October/April harvest), accounts approximately 70% of the crop in this region, in addition to other cultivars known as *verna* (April/June harvest) and *rodrejos* (September/November harvest), which account for the remaining balance of the nation's crop. Essential oil is primarily recovered from *primofiori*, or *fino*, cultivars, but should not be confused with lemons of similar denomination in Italy.
- Turkey produces an "Italian-type" lemon resembling the *femminello* in addition to *lomas* and others grown in the Mersin districts.
- Cyprus produces the *eureka*, *memele* and *laphitos* selections.
- Israel produces the *eureka* and *villafraanca* lemon types.
- Greece produces the *adamopolus* and *carystos* types, amongst others.

The production of lemons outside of the Mediterranean basin: In the northern hemisphere, the US produced and popularized the Lisbon lemon variety in California in the 1870s, later expanding to the Arizona desert areas

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where production was restricted to winter and early spring. However, eureka cultivars have, in recent decades, surpassed the Lisbon type in importance.

In the southern hemisphere, Argentina, Brazil, Uruguay, Chili and countries representing the Mercosur economic community, have shown to have a rather enormous capacity for lemon-production expansion. In particular, Argentina has become the world's leading producer in recent years. In these countries the most important cultivars are genova, eureka, Lisbon, siciliano and villafranca.

There are other nations that should be mentioned because of expected increases in their lemon production. This group includes Mexico, Australia, China, Ivory Coast and South Africa, expected to produce significant quantities of eureka and Lisbon selections.

Essential Oil Extraction Technologies

Sicily has long been the focus of lemon-oil processing with its "sponge" extraction method, a classical hand technique. This method begins when the fruit is cut in half and separated from the pulp by means of cavatura, a manual process that consists of the separation of pulp from the peel made with sharp-edged spoons called rastrelli. Manual labor is used for the pressing of the rinds against a sponge placed in a terracotta container called a concolina. This is where the oil and fluids are collected. The oil is finally recovered by decantation. Four to five h are necessary to treat approximately 100 kg of peels, not counting yield losses.

Because of rising labor and materials costs and the need to increase yields, avenues of mechanized production processes were explored. Perroni-Paladini (1908), followed by Lo Castro, Marisca, and, later, Speciale and Indelicato, developed machines with a higher working capacity (approximately 1 ton per h). Although differing in mechanical principles, these machines generally consisted of two rollers on which a special chain with elastic elements rotated.

In such a machine, the peels previously deprived of juicing were carried with a rolling movement between chains and fixed horizontal-ribbed plate. The process was performed under water sprays. The emulsion was recovered and then sent into centrifuge. The essential oil that was obtained was named sfumatrice.

With the application of still more advanced technological principles, Speciale and Indelicato set up other units such as the "super sfumatrice" and, quite recently, the AZS-204 integrated unit, for the contemporary authorized extraction of juice and oil with a working capacity of approximately 2 tons per h. In this machine, the fruit is cut in two halves by a fixed blade, falling into shaped cups allowing rotating squeezers to extract the juice. The rinds are then conveyed towards a fixed plate and a roller. Under water sprays, oil is collected and emulsion is sent for separation in a centrifuge. Trials are ongoing to further optimize and exploit essential oils from the whole fruit.

Ando, Avena, and, more recently, Speciale and Indelicato, succeeded in developing new techniques named pelatrice, now widely used amongst citrus-processing operations both in Italy and abroad. In this process, the fruit enters the machine randomly. Inside, there are three pairs of holed,

stainless-steel drums rotating in opposite directions, forcing the fruit to rebound in all directions. Water sprays remove the oil, forming an emulsion that passes through a finisher before centrifugation. The process has been named polycitrus by Indelicato.

In a later refinement of process, the Food Machinery Corp. developed the F M C-in-Line equipment. The process extracts oil and juice simultaneously. Extractors are generally equipped with four extraction heads, with the most important components represented by the upper and lower cups. The upper cup is mobile, able to compress the fruit during a downward motion. The cutters, spray rings, strainer and orifice tubes are also important. Upper and lower cutters effect cuts in the peel during the descending movements of the upper cup, thus allowing displacement of juice into the strainer tube which will be compressed during the synchronized vertical ascending movement of the orifice tube. Separately, a stream containing the oil is also produced when the cells are ruptured during the upper descending movement with the consequent release of the oil to the exterior.

Another process worth mentioning is named torchio.^b It consists of two screws rotating in opposite directions, forcing the rinds to proceed under regulated pressure. The emulsion is passed through a finisher in order to eliminate the coarse residuals. These are the primary extraction methods in obtaining cold-pressed oils.

Sfumatrice, pelatrice and torchio represent nearly 80% of the working equipment in Italy. FMC holds the remaining 20% market share. However, FMC has been introduced more successfully in the US, South America and other countries around the world (approximately 75% are used primarily for oranges).

I feel it is worthwhile to describe a method widely extended among Italian processing industries for the recovery of essential oil by means of distillation. We owe this patent to Peratoner & Sgarlata^c. The basic materials for this process are waste from treated peels and fruit not suitable for mechanical manufacturing. The process is conducted by reduced-pressure distillation (maximum 55°C) with the recovery of oil accomplished through the density difference in a collection vessel. The oil, known either as distilled or peratoner, is yielded in amounts varying between 0.07%-0.10%. Such a process is not being used outside of Italy, with the exception of some transforming industries in the US and Argentina.

World Production in Selected Countries (1989/1998)

In Tables 1-15, total fruit production, fresh-fruit consumption (both export and domestic), processing and corresponding quantities of oil obtained (respectively in %) are presented for several nations. These Tables, overall, evidence the evolution of lemon oil production over the same general period with its gradual increase or decrease in main-growing countries.

^bTorchio is manufactured by Faso, Palermo, Sicily, Italy and Speciale & Indelicato, Giarre, Catania, Sicily, Italy

^cPeratoner & Sgarlata, Palermo, Sicily, Italy

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Table 1. Italy

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export		Domestic		Processed		Oil	Exp.
1989	750.000	82.500	11.00%	442.500	59.00%	225.000	30.00%	800T.	612T.
1990	685.000	73.350	11.00%	356.500	52.05%	253.100	36.95%	890T.	704T.
1991	655.000	59.950	9.15%	378.900	57.85%	216.150	33.00%	760T.	788T.
1992	786.000	64.060	8.15%	449.200	57.15%	272.740	34.70%	950T.	760T.
1993	825.000	74.250	9.00%	488.000	59.15%	262.760	31.95%	920T.	945T.
1994	767.000	67.658	8.82%	438.570	57.18%	260.800	34.00%	910T.	829T.
1995	614.000	46.050	7.50%	310.070	50.50%	257.800	42.00%	900T.	859T.
1996	699.000	46.130	6.60%	324.330	46.40%	328.530	47.00%	1150T.	1096T.
1997	723.000	43.000	5.95%	370.000	51.18%	310.000	42.89%	1080T.	985T.
1998	620.000	30.000	4.84%	250.000	40.32%	340.000	54.84%	1200	950T.

Comparison of oil production year 1989 versus 1998: +37.88%

Table 2. Spain

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export		Domestic		Processed		Oil
1989	720.000	354.900	49.30%	295.200	41.00%	69.850	9.70%	229
1990	700.000	434.000	62.00%	196.000	28.00%	70.000	10.00%	230
1991	588.600	307.250	52.50%	191.300	32.50%	90.000	15.00%	292
1992	654.000	327.000	50.00%	223.360	34.00%	104.640	16.00%	335
1993	727.000	378.000	52.00%	247.180	34.00%	101.780	14.00%	330
1994	662.000	397.200	60.00%	165.500	25.00%	99.300	15.00%	325
1995	578.000	335.240	58.00%	161.840	28.00%	80.920	14.00%	270
1996	648.000	440.640	68.00%	97.200	15.00%	110.160	17.00%	360
1997	528.000	400.000	75.78%	70.000	13.26%	58.000	10.99%	205
1998	667.000	525.000	78.72%	62.000	9.30%	80.000	12.00%	280

Comparison of oil production year 1989 versus 1998: +22.5%

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Table 3. Cyprus

Lemon Repartition (in Metric Tons and Percentages)								
Year	Fruit	Export		Domestic		Processed		Oil
1989	61.000	41.780	68.50%	7.020	11.50%	12.200	20.00%	42
1990	55.000	31.900	58.00%	11.00	20.00%	12.100	22.00%	42
1991	56.000	37.800	67.50%	8.120	14.50%	10.080	18.00%	35
1992	42.000	28.980	69.00%	8.400	20.00%	4.620	11.00%	16
1993	45.000	30.600	68.00%	8.550	19.00%	5.850	13.00%	20
1994	54.500	39.785	73.00%	6.540	12.00%	8.175	15.00%	27
1995	38.000	26.980	71.00%	4.180	11.00%	6.840	18.00%	23
1996	33.000	20.130	61.00%	7.920	24.00%	4.950	15.00%	17
1997	25.000	12.000	48.00%	6.000	24.00%	7.000	28.00%	25
1998	39.000	26.910	69.00%	6.240	16.00%	5.850	15.00%	20

Comparison of oil production year 1989 versus 1998: -47.70%

Table 4. Greece

Lemon Repartition (in Metric Tons and Percentages)								
Year	Fruit	Export		Domestic		Processed		Oil
1989	189.000	111.510	59.00%	39.690	21.00%	37.800	20.00%	123
1990	269.000	134.500	50.00%	94.150	35.00%	40.350	15.00%	130
1991	107.000	74.900	70.00%	14.980	14.00%	17.120	16.00%	58
1992	120.000	57.000	47.50%	42.000	35.00%	21.000	17.50%	68
1993	145.000	73.950	51.00%	55.100	38.00%	15.950	11.00%	55
1994	135.000	84.982	62.95%	24.975	18.50%	25.043	18.55%	85
1995	133.000	60.000	45.10%	58.000	43.62%	15.000	11.28%	50
1996	148.000	52.000	35.14%	80.000	54.05%	16.000	10.81%	55
1997	153.000	52.00	33.99%	58.000	37.91%	43.000	28.10%	135
1998	158.000	35.000	22.15%	93.000	58.86%	30.000	18.99%	100

Comparison of oil production year 1989 versus 1998: -18.69%

Table 5. Israel

Lemon Repartition (in Metric Tons and Percentages)								
Year	Fruit	Export		Domestic		Processed		Oil
1989	43.900	18.875	43.00%	8.340	19.00%	16.680	38.00%	55
1990	34.000	11.220	33.00%	8.840	26.00%	13.940	41.00%	45
1991	37.500	13.500	36.00%	10.125	27.00%	13.875	37.00%	44
1992	19.100	10.500	55.00%	3.250	17.00%	5.350	28.00%	18
1993	25.000	15.000	60.00%	4.000	16.00%	6.000	24.00%	17
1994	22.700	13.847	61.00%	3.859	17.00%	5.000	22.00%	13
1995	20.000	13.000	65.00%	3.000	15.00%	4.000	20.00%	12
1996	17.000	3.000	17.65%	10.100	59.40%	3.900	22.95%	13
1997	20.000	4.00	20.00%	13.000	65.00%	3.000-	15.00%	10
1998	18.000	2.000	11.12%	13.000	72.21%	3.000	16.67%	10

Comparison of oil production year 1989 versus 1998: -82.00%

According to reliable sources of information collected during 1998, approximately 25 million tons of citrus fruits have been processed worldwide, of which 7% is represented by lemons. The US, Argentina, Brazil, South Africa and the Ivory Coast are reported to be the countries having the highest percent of lemons entering industrial use,

whereas in other countries production has been oriented towards fresh-fruit markets.

In recent years, Italy has joined the aforementioned countries with an important share of the crop contracted with processors. This is a result of the decline in export potential of fresh fruit to Central and Eastern Europe,

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Table 6. Turkey

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export		Domestic		Processed		Oil
1989	316.000	118.500	37.50%	181.700	57.50%	15.800	5.00%	50
1990	325.000	180.375	55.50%	130.000	40.00%	14.625	4.50%	47
1991	290.000	174.000	60.00%	104.400	36.00%	11.600	4.00%	38
1992	291.000	139.680	48.00%	136.770	47.00%	14.550	5.00%	47
1993	260.000	137.800	53.00%	106.000	41.00%	15.600	6.00%	50
1994	250.000	187.000	74.80%	45.000	18.00%	18.000	7.20%	59
1995	360.000	154.800	43.00%	174.600	48.50%	30.600	8.50%	95
1996	350.000	180.250	51.50%	145.250	41.50%	24.500	7.00%	78
1997	401.000	110.000	27.44%	264.000	65.84%	27.000	6.74%	86
1998	280.000	60.000	21.43%	197.600	70.57%	22.400	8.00%	72

Comparison of oil production year 1989 versus 1998: +44.00%

Table 7. US

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export		Domestic		Processed		Oil
1989	753.900	135.700	18.00%	331.720	44.00%	286.500	38.00%	985
1990	655.000	144.100	22.00%	275.100	42.00%	235.800	36.00%	820
1991	756.200	136.115	18.00%	385.660	51.00%	234.420	31.00%	820
1992	806.000	135.000	16.75%	370.350	45.95%	300.640	37.30%	1030
1993	863.000	140.150	16.24%	332.860	38.57%	425.110	49.26%	1485
1994	851.500	108.400	12.73%	325.010	38.17%	418.090	49.10%	1460
1995	900.000	119.700	13.30%	348.300	38.70%	432.000	48.00%	1515
1996	898.000	122.570	13.65%	353.360	39.35%	422.070	47.00%	1475
1997	789.000	123.550	15.66%	298.560	37.84%	366.885	46.50%	1280
1998	848.000	116.000	13.68%	345.475	40.74%	386.520	45.58%	1360

Comparison of oil production year 1989 versus 1998: +38.08%

Table 8. Argentina

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export		Domestic		Processed		Oil
1989	500.000	50.000	10.00%	100.000	20.00%	350.000	70.00%	1200
1990	560.000	56.000	10.00%	84.000	15.00%	420.000	75.00%	1365
1991	571.000	68.000	11.91%	70.000	12.26%	432.989	75.83%	1400
1992	585.000	73.000	12.48%	102.492	17.52%	409.500	70.000%	1380
1993	607.500	90.000	14.82%	109.350	18.00%	408.118	67.18%	1400
1994	667.000	95.047	14.25%	113.057	16.95%	458.896	68.80%	1600
1995	741.000	164.950	22.26%	115.890	15.64%	460.160	62.10%	1625
1996	720.000	166.000	23.06%	87.910	12.21%	466.050	64.73%	1660
1997	851.000	168.840	19.84%	137.520	16.16%	544.650	64.00%	1900
1998	896.000	179.200	20.00%	132.610	13.00%	600.320	67.00%	2100

Comparison of oil production year 1989 versus 1998: +75.00%

previously a promising outlet. Spain and several other producers replaced these areas. An accurate calculation of today's world production for lemon oil is precluded by some lack of statistical information, although it is believed that it cannot be considered far away from being on or around 5,600-5,800 tons per year.

If we consider the development of lemon oil production over these last ten years, it can be confirmed that availability on the international market has increased by nearly 47% (during 1989: approximately 4,000 tons). Argentina, Brazil and Spain have been the primary contributors to this trend, increasing plantations because of favorable climatic condi-

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Table 9. Brazil

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export	Domestic	Processed	Oil
1989	26.000		2.000	22.100 84.62%	75
1990	43.00		2.000	38.700 90.00%	132
1991	48.000		3.000	38.400 80.00%	135
1992	70.000		3.000	64.400 92.00%	220
1993	68.000		4.000	59.840 88.00%	210
1994	69.500		3.000	63.940 92.00%	225
1995	70.000		2.000	63.000 90.00%	220
1996	77.000		2.000	68.530 89.00%	245
1997	73.000		3.000	70.000 95.90%	250
1998	76.000		2.000	74.000 97.37%	260

Comparison of oil production year 1989 versus 1998: +246,78%
 No indication for fruit export available.

Table 10. Uruguay

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export	Domestic	Processed	Oil
1989	19.000	8.550 45.00%	1.235 6.50%	9.025 47.50%	30
1990	42.000	16.800 40.00%	6.720 16.00%	18.480 44.00%	65
1991	39.000	15.600 40.00%	7.020 18.00%	16.380 42.00%	56
1992	24.000	8.040 33.50%	4.440 18.50%	11.520 48.00%	39
1993	20.000	10.000 50.00%	2.500 12.50%	7.500 37.50%	26
1994	19.000	11.020 58.00%	3.800 20.00%	4.180 22.00%	15
1995	40.000	17.000 42.50%	7.000 17.50%	16.000 40.00%	52
1996	38.000	17.000 44.74%	4.000 10.52%	17.000 44.74%	57
1997	51.000	30.000 59.00%	10.000 19.61%	10.910 21.39%	38
1998	53.000	35.000 66.05%	12.000 22.65%	6.000 11.30%	21

Comparison of oil production year 1989 versus 1998: -30.00%

Table 11. Ivory Coast

Lemon Repartition (in Metric Tons and Percentages)

Year	Fruit	Export	Domestic	Processed	Oil
1989	21.000			100.00%	95
1990	16.700			100.00%	75
1991	14.700			100.00%	66
1992	13.300			100.00%	60
1993	15.800			100.00%	71
1994	13.400			100.00%	60
1995	15.500			100.00%	70
1996	16.700			100.00%	75
1997	18.000			100.00%	81
1998	19.600			100.00%	88

Comparison of oil production year 1989 versus 1998: -7.36%
 No export of fresh fruit recorded.

Table 12. South Africa

Year	Fruit	Lemon Repartition (in Metric Tons and Percentages)				Oil		
		Export		Domestic			Processed	
1989	55.000	30.250	55.00%	4.675	8.50%	20.075	36.50%	68
1990	56.000	29.120	52.000%	4.480	8.00%	22.400	40.00%	75
1991	54.000	31.860	59.00%	3.240	6.00%	18.900	35.00%	64
1992	61.000	30.070	49.30%	8.050	13.20%	22.875	37.50%	76
1993	71.500	42.900	60.00%	3.575	5.00%	25.025	35.00%	84
1994	70.000	39.900	57.00%	7.700	11.00%	22.400	32.00%	74
1995	71.000	42.950	60.50%	8.045	11.50%	20.000	28.00%	68
1996	77.00	46.200	60.00%	8.470	11.00%	22.330	29.00%	73
1997	74.000	33.000	44.60%	14.000	18.92%	27.000	36.48%	85
1998	78.00	36.00	46.16%	14.000	17.95%	28.000	58.89%	90

Comparison of oil production year 1989 versus 1998: +32,38%

Table 13. Australia

Year	Fruit	Lemon Repartition (in Metric Tons and Percentages)				Oil		
		Export		Domestic			Processed	
1989	36.000	3.240	9.00%	15.480	43.00%	17.280	48.00%	56
1990	32.100	4.000	12.50%	9.470	29.50%	18.620	58.00%	60
1991	34.000	5.000	14.75%	10.965	32.25%	18.020	53.00%	58
1992	31.000	7.130	23.00%	8.060	26.00%	15.810	51.00%	52
1993	37.000	8.000	21.60%	11.020	29.78%	17.990	48.62%	58
1994	41.000	12.000	29.28%	13.530	33.00%	15.470	37.72%	50
1995	40.000	8.400	21.00%	16.000	40.00%	15.600	39.00%	50
1996	42.000	8.000	19.05%	20.160	48.00%	13.840	32.95%	45
1997	38.000	3.000	7.90%	19.000	50.00%	16.000	42.10%	52
1998	39.000	3.110	7.98%	19.890	51.000%	16.000	41.02%	50

Comparison of oil production year 1989 versus 1998: -32.00%

tions, soil, mechanization, regular rainfall and irrigation possibilities.

Mexico, China and Australia have also been modestly important in this process. Sicily, Spain and Greece, the largest processors in the Mediterranean basin, appear to have reached a stagnation position. Therefore, the new sources have an impact on the international market with gradual improvement in product quality. These improvements are attributed to the use of modern extraction equipment, strongly suggesting that the supply capacity will be sufficiently large and flexible to assist any level of demand.

The complete exploitation of lemon fruit could represent a promising signpost in lemon processing. However, not every country has yet completed research work to find the proper output of oils and juices, representing roughly 60% of total fruit processing. Countries like the US have put emphasis on the importance of developing juices, representing a rather high percent of processing programs. Similar examples should be followed by European and developing countries in the Southern Hemisphere, where the percentages are decidedly lower.

Therefore, apart from the oil and juice, other lemon-derived products should be included in studies for develop-

ment, including juices in powder form (dehydrated), pulps, cells, peel segments, comminuted juices, peels in brine, candies, pectines, flavonoids, enzymes and cattle feed. Lemon essence, which is the soluble fraction of the flavor complex recovered during the stage of juice concentration, and water-phase oil are important products for the consuming industries. This is true because not all processing industries appear to be equipped with the appropriate devices.

It is worth mentioning lemon leaf oil (petitgrain) that Ciotronnier obtained by steam distillation from the tender leaves and twigs (same botanical species as lemon). Distillation takes place in Italy and Spain on the occasion that trees are trimmed in commercial quantities. The oil is rich in citral and is primarily used in formulations where a fresh, floral quality is required.

Generally, uniformed qualities of oil are supplied because industry emphasis remains on uniformity of flavors. This is made difficult because large quantities of fruit are available from widely varying growing areas. Consumer requirements are such that bulk oils are sampled before each shipment. Different conditions, however, may create a remarkable difference in oils. By their characteristics, based on extraction technology and physico-chemical prop-

Table 14. China

Lemon Repartition (in Metric Tons and Percentages)					
Year	Fruit	Export	Domestic	Processed	Oil
1989	146.700			14.670 10.00%	47
1990	153.200			16.852 11.00%	55
1991	149.500			16.445 11.00%	54
1992	152.000			14.900 9.80%	48
1993	168.000			13.450 8.00%	44
1994	177.000			23.010 13.00%	73
1995	182.000			20.000 11.00%	65
1996	179.000			21.480 12.00%	69
1997	190.000			22.800 12.00%	73
1998	187.000			18.700 10.00%	62

Comparison of oil production year 1989 versus 1998: +31.9%²
Fruit and oil production mainly intended for domestic consumption.

Table 15. Minor producers

Lemon Repartition (in Metric Tons and Percentages)								
Year	Fruit	Export	Domestic	Processed	Oil			
1989	180.000	124.200 69.00%	30.600 17.00%	25.200 14.00%	82			
1990	200.000	142.000 71.00%	30.000 15.00%	28.000 14.00%	88			
1991	185.000	116.550 63.00%	37.000 20.00%	31.450 17.00%	100			
1992	215.000	144.000 67.00%	38.700 18.00%	32.250 15.00%	103			
1993	197.000	126.080 64.00%	37.430 19.00%	35.460 18.00%	113			
1994	216.000	151.200 70.00%	32.400 15.00%	32.400 15.00%	103			
1995	209.000	142.120 68.00%	37.620 18.00%	29.260 14.00%	94			
1996	213.000	151.230 71.00%	34.080 16.00%	27.690 13.00%	90			
1997	221.000	143.650 65.00%	46.410 21.00%	30.940 14.00%	100			
1998	220.000	154.000 70.00%	33.000 15.00%	33.000 15.00%	110			

Comparison of oil production year 1989 versus 1998: 34,25%
Under minor producers: Mexico (expanding fast), Peru, Chili, Morocco, Egypt, Gasa, Tunisia, Swaziland, Malawi, Zimbabwe, and New Zealand.

erties, it is now possible to recognize the specific growing areas through testing of oils. Variations may also occur from one year to another owing as climatic conditions or with the proceeding of the seasons changes.

Italian expressed oils, for instance, obtained at the beginning of the harvest (winter months) are believed to be of very consistent quality, possessing a high aldehyde content and optical rotation. This decreases with the ripening of the fruit. Established properties for varieties such as spring or summer, will differ because of lower aldehyde levels, specific gravity and optical rotation. However, odor and flavor may be considered superior to the finest winter grades, especially when freshly produced.

Considering the many cultivars around the world, differences between the characteristics of commercially available oils are to be attributed more to their various geographic areas than botanical sources. With improvements of processing techniques, following the “sponge” extraction, it is the general opinion that sfumatrice oil is normally of superior quality. It carries a premium price on the international market above any other type, including FMC or pelatrice.

A good perfumer’s nose will always appreciate this oil,

with preference for the Sicilian cold-pressed winter oil, over similar ones available from third countries. However, because sfumatrice processing is not practiced widely since the introduction of torchiato oil, recent research work has assessed a similarity both in olfactive properties and their main components. FMC oil shows a close resemblance to pelatrice oil, in which higher content of oxygenated compounds and lower hydrocarbons are to be found. Such peely or slightly juicy notes appear quite acceptable for soft drink manufacturers.

Similarities and Differences Between Lemon Oil Types and Features

Recently, a considerable amount of oil blending has taken place because users may consider different oils closely comparable and, therefore, interchangeable. Such is the case for Californian and Argentinian oils. Brazilian quality parameters are different than other oils available in the southern hemisphere because of specific climatic factors. Brazil oils closely resemble those of the Ivory Coast because both are produced near the equator, possess a strong greenish color and retain zesty prevailing notes, limiting

the use in flavors and compounds. On the contrary, appreciable oil quantities are available from South Africa, a situation that similarly exists in Israel and Australia. Uruguayan oil is reported to be similar to Italian oils. Mediterranean-basin countries such as Greece, Cyprus, Turkey and Spain, have a preeminent position on the international market with oils possessing widely varying qualities yet largely accepted by consuming industries.

Lemon Oil Trading: Traditional Applications

The main field of application for lemon oil is represented by the soft drink industry, where it is used in a whole range of carbonated beverages, sodas, squashes, cordials and the like. Elsewhere in the flavoring field, the oil is widely used in products such as confectionery, pie fillings, baked goods, desserts, ice cream, liquors, prepared fruit flavors, pharmaceuticals and many others. In cheaper products, use is being made of lemon by-products such as terpenes and other residues of the concentration process. In boiled sweets, for example, where the use of heat is required, distilled oil is more likely to be used, since the characteristics of expressed oils are liable to change under such conditions.

Lemon oil is also used in perfumery applications, though on a smaller scale compared to flavors. These applications include perfumes, eau de cologne, cosmetics, soaps, aerosols, toiletries, room fresheners, detergents, liquid soaps and solvents, as well as a range of industrial and domestic products in which it is important to impart a fresh note to the finished products. Lemon terpenes may also be used in this field, where they present fewer problems than in flavors. The latest usage of lemon oil has been in the field of aromatherapy.

Lemon oil usage in the US, quoted in 1997, stated that 60% of product was used in soft drinks, 15% cakes and biscuits, 14% confectionery, five percent flavors, three percent perfumery, two percent pharmaceuticals, and one percent others. Percentages vary from country to country, however such information is not available.

Import Countries: World Price Evolution

On the basis of available information, the volume of world imports for lemon oil has been estimated to average around 4,500-5,000 tons per year. This holds true if we take into consideration oil availability during 1998, excluding consumption of each producing country. During these last ten years, a substantial number of alternative suppliers have covered the increasing global demands of consumer industries, creating a strong competition with traditional sources of supply.

Today, with the increased availability of fruit crops, price trends have been such that a certain stability over a longer period has resulted. In fact, during recent years, lemon oil prices on the international market have gradually decreased with some exceptions. This confirms that larger portions of processing operations have been taken in those areas in which industrial costs are lower (ie. Argentina, Brazil).

Several consumer industries, if not also producers, appear to have imported more oil than they consume. These

entities tend to re-export this extra intake to other countries. These importers have become dealers, exporting extra product to fulfill orders.

Expectations for the Forthcoming Decade

Looking into the future, it appears not so difficult to predict that worldwide consumption of lemon oil should be showing a further growth rate during the next ten years or so. Whether the industries will be able to supply the growing market in appropriate volumes and accessible prices, is something that remains to be seen. Analyzing the situation carefully, it may be assumed that the production of lemon oil in the world probably will not be sufficient to cover the demands of industry.

Although lemon juice demand may be nearly stable in developed countries over the next few years, there will surely be an increase in consumption in developing countries for lemon-based products where lemon oil will represent an important ingredient as a flavoring agent. I refer not only to Eastern European countries and the Russian Federation, but also China, India and Southeast Asia, which are all expected to become larger consumers of industrialized commodities.

The expected growth could reach two percent, if not more. New trees should be planted in areas where climatic conditions will allow to support future demands. With increased crops expected in main growing countries, a certain stability should be guaranteed in respect to regular availability and favorable price tendencies. This would result in acceptance by consumer industries of all fields and applications.

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