

IFEAT SOCIO-ECONOMIC REPORT

# LEMON

CITRUS LIMON (L.) BURM. F | FAMILY: RUTACEAE

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## INTRODUCTION

Citrus species are grown throughout the world and citrus is the most important tree fruit crop. Citrus oils are the largest group of essential oils and lemon is the second largest citrus oil after orange and its derivatives. Lemon oil is formed by cells inside the peel or rind of the fruit. The lemon fruit is obtained from the lemon tree (*Citrus limon* (L.) Burm. F), the origins of which are a mystery with possible sources being cited as southern China, the eastern Himalayas, and possibly a hybrid of Indian lemons. Lemon was unknown during the Roman Empire and was introduced to Persia at the beginning of the 12th century. During the following centuries it spread to North Africa, Spain and southern Italy, whilst Columbus introduced lemon to the Americas in the late 15th century. Lemon was introduced to Florida in the early 16th century.

Lemon trees have a long gestation period and can grow to a height of between 3-6 metres depending on species. A typical citrus tree yields essential oil after 4-5 years and continues to yield oil until it is about 20-25 years old. Thus decisions made 20 years ago can affect the industry today and decisions being made today can continue to affect the industry for 20 years. Except for Argentina, most citrus farmers aim to sell their lemons into the fresh fruit market, with fruit not meeting specifications being processed into juice, and the essential oil is a by-product of juice production. Citrus processing and the recovery of citrus by-products (e.g. juice, peel oil, aroma and essence oils, frozen pulp cells and cattle feed pellets) is an important economic component of citrus production, especially when large volumes of citrus are processed. Average global data suggests that each tonne of lemon fruit yields 48-52 kg of lemon juice, 2.4-4.5 kg of lemon oil and 50-52 kg of dehydrated lemon peel.

Thus, in contrast to most essential oils, which are extracted by steam distillation, citrus oils are extracted as a by-product of juice extraction by centrifugation, producing cold pressed (CP) oil. Lemon oil is generally extracted, without heat, by cold expression of the peel of the fresh lemon fruit and captured in water. Usually Brown, JBT (FMC) or Excel extractors are used to express the oil although other types of extractors can be used, including the pelatrice system. The resulting oil and water emulsion is sent to a series of centrifuges to separate the oil and water. Some 0.30-0.55% of CP oil (i.e. 3-5 kg of oil per 1,000 kg of fruit) can be extracted from the skin with no thermal treatment and has the golden yellow colour of the lemon. The colour of the oil is partly dependent on the maturity of the fruit when processed and the type of extraction equipment used. The more aggressive the extraction process (e.g. Brown BOE and JBT MORE) the darker the oil.

Very small volumes of lemon oil are also obtained by steam distilling the peel. This is known as distilled lemon oil and has no colour. In addition, lemon essence oil can be isolated from lemon juice during the evaporation process. This oil is water white in colour and very juicy.

Crude lemon oil is further processed into other products, many of which are used as F&F ingredients. One process is fractionation using complex distillation columns – known as folding oils – whereby the flavour components including d-limonene are separated for use in the beverage and confectionery industries. D-limonene is used as a natural cleaning agent or degreaser and can be used in emulsions. Natural isolates are also fractionated from the oil, which are used by flavour houses to enhance flavour profiles. Citrus oils are made into various forms of

flavours and fragrances depending on the application, e.g. lemon fragrance for the dishwasher industry or water-soluble flavours for soft drinks. Lemons have practically no waste, with most parts being used. Much of the industry is fully committed to a circular economy strategy. Indeed, water used during processing is reused to irrigate lemon orchards nearby the processing plants.

The chemical constituents of lemon oil include 65-75% d-limonene, 3.5-5% citral, 3-4.5% other volatile terpenes (terpinene, pinene, sabinene, myrcene, linalool) and 2% non-volatiles. Citral and some of the other volatile compounds give lemon oil its characteristic aroma and flavour. Constituents can vary between lemon varieties, extraction process, region, weather and water availability. The ISO Standard 855:2003 Oil of Lemon [*Citrus limon* (L.) Burm. f.] obtained by expression gives the chemical components listed in the table opposite.

## USES

Lemon has multiple uses, mainly as fresh fruit, then as juice followed by essential oil and dehydrated peel. Lemon oil is used in a wide range of products and industries, including flavour, fragrance, aromatherapy, pharmaceuticals, cosmetics, agriculture and animal feeds. Lemon is a major flavour in most countries and has excellent health properties. It is estimated that approximately three quarters of lemon oil is used in flavouring, especially in food and beverages, particularly soft drinks. It gives the lemon flavour to throat lozenges, and other sweets as well as chewing gum. Salad dressings and bakery products are also flavoured with lemon oil. Its fresh flavour is sometimes used to mask tastes in health supplements containing fish oils. Alongside its culinary uses it is found in a range of household and industrial

## LEMON OIL CHEMICAL CONSTITUENTS

Values in percent

COMPONENTS	AMERICAN TYPE		MEDITERRRANEAN TYPE				EQUATORIAL			
	COASTAL TYPE		DESERT TYPE		SPAIN		ITALY		IVORY COAST, BRAZIL	
	min.	max.	min.	max.	min.	max.	min.	max.	min.	max.
<b>α-Thujene</b>	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5
<b>α-Pinene</b>	1.5	2.5	1.4	2.5	1.5	3.0	1.5	3.0	1.4	3.0
<b>Sabinene</b>	1.5	2.5	1.3	2.5	1.5	3.0	1.5	3.0	1.4	3.0
<b>β-Pinene</b>	9.0	14.0	10.0	13.0	10.0	16.5	10.0	16.5	7.0	16.0
<b>p-Cymene</b>	0.05	0.35	0.01	0.35	traces	0.40	0.05	0.35	0.05	0.35
<b>Limonene<sup>a</sup></b>	63.0	70.0	70.0	80.0	60.0	70.0	60.0	68.0	59.0	75.0
<b>γ-Terpinene</b>	8.3	9.5	6.5	8.0	8.0	12.0	8.0	12.0	6.0	12.0
<b>α-Terpineol</b>	0.1	0.25	0.06	0.15	0.09	0.35	0.1	0.3	0.0	0.4
<b>Neral</b>	0.6	0.9	0.3	0.6	0.4	1.0	0.6	1.2	0.2	1.2
<b>Geranial</b>	1.0	2.0	0.5	0.9	0.6	2.0	0.8	2.0	0.5	2.0
<b>β-Bisabolene</b>	0.45	0.9	0.4	0.7	0.45	0.9	0.45	0.9	0.20	0.9
<b>Neryl acetate</b>	0.35	0.6	0.3	0.5	0.3	0.6	0.2	0.5	0.1	0.5
<b>Geranyl acetate</b>	0.2	0.5	0.1	0.3	0.2	0.65	0.3	0.65	traces	0.3

**Note:** The chromatographic profile is normative, contrary to typical chromatograms given for information in Annex A.

<sup>a</sup> This is regarded as being completely D-limonene by independent chemical and physical analysis.

cleaning products because of its ability to disinfect, deodorise, remove grease and dissolve wax and grime. Lemon is also used in aromatherapy to enhance mood and its anti-bacterial properties lead to use in medicinal applications including antioxidant recipes. Its fresh and zesty note leads to its use in fragrances, *eau de cologne* and candles.

## QUALITY

The quality of lemon oil is influenced by several factors. Like most oils, a key factor is the percentages of various aromatic components, mainly isomers of citral including neral, geranial and other aldehydes, which are quite unstable and volatile. Naturally these give values anywhere from 1.5-4.0%. In more quality-conscious markets the "purity" is also important, which can be determined using gas chromatography (GC) analysis. An increasingly key quality issue relates

to the level of agricultural residues (ARs) both on the fruit and in the oil. Lemon oil oxidises very easily, so proper storage is important, otherwise both the colour and the aroma can be affected.

Quality has become increasingly important as consumer and regulatory demands have become more stringent. Almost every year new parameters are set which have to be complied with along with the old specifications. Moreover, quality specifications can vary between different markets and end uses. Where producers concentrate on the fresh fruit market there are issues relating to the use of substances that are not globally acceptable. Considerable efforts are being made, particularly in Argentina and Spain, to reduce pesticide usage and the impact of processing and residue concentration on quality (see AR section below).

## GROWTH AND PRODUCTION CHARACTERISTICS

### Varieties

The botanical name is *Citrus limon* and the main varieties grown around the world are:

- *Eureka* and *Lisbon*. These are the most common ones, grown in Argentina, USA, South Africa, and Mexico.
- *Genova* is similar to *Eureka* and is grown in Argentina.
- *Limoneira* is a high oil variety grown in Argentina and Mexico.
- *Feminellos* and *Monachellos* are grown in Italy.

- The similar *Fino* variety is the main variety grown in Spain (about 70%) along with the thicker-skinned *Verna* (30%), which is exclusive to Spain.
- *Interdonatos*, *Lamas* and a hybrid called *Meyer* are grown in Turkey, the latter also in California.
- In Brazil, the lemon variety is *Siciliano*, although this is not originally an Italian variety, but was developed in Florida.

It takes about five years for a lemon tree to produce a full crop, so completely new lemon oil origins are unlikely to spring up by surprise. Since lemons are grown in both the northern and southern hemispheres and on all continents, they are available throughout the year. Argentina and South Africa are the major southern hemisphere producers and harvesting and processing is usually undertaken from April to September. The major northern hemisphere producers are, in scale of production, Spain, the USA, Turkey, Italy and Mexico, with harvesting and processing taking

place from November to March, although some Italian production stretches into August. There are two seasons in Spain giving them around nine months of harvesting during the year. The *Fino* and *Primafori* varieties run from October to April and the *Verna* variety from April to July.

**GLOBAL LEMON PRODUCTION**

Lemons are produced in a large number of countries worldwide. Some very large producers of lemons, particularly China and India, produce negligible amounts of lemon oil. Production of lemon oil is dominated by Argentina, Spain, Italy, the USA and South Africa. Argentina and Spain dominate world production, with approximately 70% of global output. The USA, Turkey and Italy are also important lemon growers. Currently, these six countries combined account for approximately 84% of world lemon production. Smaller producers are Chile, Mexico and Brazil. There are also some lemon groves found in China, India, Uruguay, Bolivia, Morocco, Greece, Israel and Portugal. Lemon usually grows best in a

Mediterranean climate characterised by hot days, cool nights and a rainy season. Lemons produced in coastal areas are usually superior to those grown in desert regions.

Data on lemon production can be confusing in part because some countries combine lemon (*Citrus limon*) and lime (*Citrus aurantifolia* or *Citrus latifolia*) together in their production data (e.g. Mexico). Limes are a similar shape but smaller like a golf ball and taste quite different; they are greener and grow in more tropical and sub-tropical areas, including Peru, Brazil, Mexico, India and Iran.

The graphic shows average annual lemon production and processing in major producing countries between 2010 and 2020 compiled by the World Citrus Organisation and AILIMPO (Asociación Interprofesional De Limón Y Pomelo). As discussed in the country profiles below, there can be substantial variations in annual production and processing mainly as a result of climatic factors, including frosts, droughts, heavy rainfall and hurricanes.

Annual lemon output, processing and exports over the past decade in the major producing countries are shown in the table below.

**WORLD MAJOR LEMON PRODUCERS AND PROCESSORS 2010/11 TO 2019/20 (METRIC TONNES)**

ARGENTINA	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	AVERAGE	%
Processing	1,360,741	1,086,146	1,099,159	603,300	1,140,287	1,209,942	1,100,000	1,400,000	1,450,000	1,150,000	1,159,958	78.8%
Local	63,687	61,071	66,936	47,574	70,307	88,152	85,000	140,000	100,000	100,000	82,273	5.6%
Export	244,105	272,450	282,179	153,445	185,264	279,543	215,000	260,000	200,000	200,000	229,199	15.6%
<b>TOTAL</b>	<b>1,668,533</b>	<b>1,419,667</b>	<b>1,448,274</b>	<b>804,319</b>	<b>1,395,858</b>	<b>1,577,637</b>	<b>1,400,000</b>	<b>1,800,000</b>	<b>1,750,000</b>	<b>1,450,000</b>	<b>1,471,429</b>	<b>100.0%</b>

SPAIN	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	AVERAGE	%
Processing	304,000	277,000	146,000	237,000	302,000	108,410	282,118	211,374	355,155	252,167	247,522	23.9%
Local	167,000	170,000	170,000	173,000	170,000	150,480	160,000	184,392	184,392	184,500	171,376	16.5%
Export	466,000	530,000	518,000	584,000	658,000	541,963	709,779	657,357	731,529	771,492	616,812	59.6%
<b>TOTAL</b>	<b>937,000</b>	<b>977,000</b>	<b>834,000</b>	<b>994,000</b>	<b>1,130,000</b>	<b>800,852</b>	<b>1,151,897</b>	<b>1,053,123</b>	<b>1,271,076</b>	<b>1,208,159</b>	<b>1,035,711</b>	<b>100.0%</b>

USA	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	AVERAGE	%
Processing	293,000	177,000	265,000	194,000	292,000	209,000	175,000	155,000	180,000	170,000	211,000	25.3%
Fresh Produce	559,000	594,000	563,000	630,000	612,000	695,000	711,000	635,000	633,000	600,000	623,200	74.7%
<b>TOTAL</b>	<b>852,000</b>	<b>771,000</b>	<b>828,000</b>	<b>824,000</b>	<b>904,000</b>	<b>904,000</b>	<b>886,000</b>	<b>790,000</b>	<b>813,000</b>	<b>770,000</b>	<b>834,200</b>	<b>100.0%</b>

ITALY	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	AVERAGE	%
Processing	110,000	100,000	66,000	88,000	70,000	77,000	55,000	80,000	72,000	80,000	79,800	15.8%
Local	286,000	350,000	316,000	419,000	427,000	438,000	400,000	445,000	408,150	315,000	380,415	75.6%
Export	30,000	70,000	29,000	39,000	47,000	40,000	35,000	45,000	47,850	50,000	43,285	8.6%
<b>TOTAL</b>	<b>426,000</b>	<b>520,000</b>	<b>411,000</b>	<b>546,000</b>	<b>544,000</b>	<b>555,000</b>	<b>490,000</b>	<b>570,000</b>	<b>528,000</b>	<b>445,000</b>	<b>503,500</b>	<b>100.0%</b>

TURKEY	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	AVERAGE	%
Processing	20,000	40,000	20,000	32,000	34,000	40,000	40,000	40,000	50,000	50,000	36,600	4.6%
Local	374,000	379,000	250,000	277,000	260,000	202,000	280,000	290,000	478,000	400,000	319,000	40.1%
Export	466,000	512,000	354,000	439,000	460,000	420,000	390,000	300,000	575,000	475,000	439,100	55.3%
<b>TOTAL</b>	<b>860,000</b>	<b>931,000</b>	<b>624,000</b>	<b>748,000</b>	<b>754,000</b>	<b>662,000</b>	<b>710,000</b>	<b>630,000</b>	<b>1,103,000</b>	<b>925,000</b>	<b>794,700</b>	<b>100.0%</b>

RSA	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	AVERAGE	%
Processing	79,204	58,756	72,015	99,861	97,898	66,000	70,000	115,000	130,000	170,000	95,873	27.1%
Local	12,644	12,621	13,149	14,108	15,127	16,000	16,000	15,000	20,000	25,000	15,965	4.5%
Export	161,236	157,682	159,404	198,345	226,105	226,000	225,000	330,000	340,000	400,000	242,377	68.4%
<b>TOTAL</b>	<b>253,084</b>	<b>229,059</b>	<b>244,568</b>	<b>312,314</b>	<b>339,130</b>	<b>308,000</b>	<b>311,000</b>	<b>460,000</b>	<b>490,000</b>	<b>595,000</b>	<b>354,216</b>	<b>100.0%</b>

**WORLD LEMON PRODUCTION AND PROCESSING AVERAGE 2010 – 2020 (METRIC TONNES)**

Argentina	Spain	USA	Turkey	Italy	RSA	Others*
Fresh 311,471	Fresh 788,188	Fresh 623,000	Fresh 758,100	Fresh 423,700	Fresh 258,342	Fresh 650,000
Processed 1,159,958	Processed 247,522	Processed 211,000	Processed 36,600	Processed 79,800	Processed 95,873	Processed 240,000
<b>Production 1,471,429</b>	<b>Production 1,035,711</b>	<b>Production 834,200</b>	<b>Production 794,700</b>	<b>Production 503,500</b>	<b>Production 354,216</b>	<b>Production 890,000</b>

**Total:** Fresh **3,813,002** Processed **2,070,753** Production **5,883,755**

\*Egypt, China, Mexico, Bolivia, Brazil, Australia, Uruguay and others.



Source: AILIMPO and World Citrus Organisation

Another major source of lemon production and processing data is the USDA global and country citrus reports (see references). Unfortunately USDA data does not disaggregate between EU countries or between Mexican lemon and lime output.

### CHALLENGES FACING LEMON PRODUCTION

There are several major challenges facing lemon production and the industry:

- Climatic factors including frosts, droughts, heavy rains and hurricanes.
- Agricultural residues (AR) issues arising from the use of pesticides and herbicides. The industry faces unclear regulation on pesticide residues and there is a need to coordinate accepted reference values as it creates market distortion and uncertainty.
- Chronic and acute pests and diseases, particularly HLB (Huanglongbing – citrus greening disease), citrus black spot (CBS) and citrus canker which affects southern producing countries, notably Argentina, South Africa and Brazil. Mediterranean Basin producing countries (especially Spain and Italy) do not suffer from chronic pests and can be considered as “phytosanitary islands”
- Alternative land use, including urbanisation.

In addition, some countries face specific challenges which are outlined in the country sections below.

### MAJOR LEMON PRODUCERS

**Argentina**  
When Ernest Guenther wrote his famous six-volume book on Essential Oils, there was negligible mention of Argentina as a lemon oil producer. Seventy years on, the country is the world’s major producer - yet another illustration of the continuous changes taking place in the world of essential oils. Over the past 50 years Argentina’s processed lemon volumes have increased significantly decade on decade, from an average annual

volume of 80,000 MT in the 1970s, to 200,000 MT in the 1980s, to 540,000 MT in the 1990s and 900,000 MT since 2000 and to over 1,000,000 MT during the years from 2015 – 2020. Recently, increased processing volumes have been facilitated not only by the growth in production but also the decision to impose higher quality fresh fruit export standards. While the average size of annual crops has increased, improved production and processing techniques are helping to maximise the yields of fruit and oil. The varieties grown, mainly *Lisboa*, *Genova* and *Eureka*, combined with the extraction equipment used, allow for an average yield of 0.5%. Annual production of lemon oil over the past decade has ranged between 4,150 MT to 6,750 MT. In recent years Argentina has usually accounted for approximately 60% of global lemon processing.

The sizeable fluctuations in the size of the Argentine crop – and hence the volume of lemon processed – can have a major impact on the global market, as the 2014 crop disaster illustrated. There were two particularly poor crops in 2010 and 2014 caused by weather events. Freezes in 2007, 2009 and 2011 impacted the following year’s crop, especially the newer trees. The drop is greater when freezes are combined with previous dry seasons. 2013 saw the biggest freeze in 60 years combined with a dry season in 2012 leading to a disastrous fall in production since these weather events affected all the trees rather than just new trees.

Alongside substantial variations in production there has been sizeable fluctuation in yields per fruit per hectare (ha). 2006 and 2007 saw some of the highest productivity levels at nearly 40 MT/ha compared with 27 MT/ha in 2010 and 18 MT/ha in 2014. A range of factors accounts for these variations including:

- Soil salinisation and/or fatigue after growing lemons for many years on the same land.
- Slow renewal of plantations in part because of limited availability of planting stock because of HLB prevention efforts and a lack of incentives for growers to replant and then have to wait several years for new fruit.

- Citrus black spot and citrus canker limit production and fresh exports.
- The use of pesticides, fertilisers and herbicides is increasingly restricted by market and legislative demands.
- Climatic factors – very high temperatures cause early fruit drop; changing rain patterns have led to droughts in spring and reduced rain in November/December, impacting fruit growth and more rain later in the season, affecting the final stages of production.

A major challenge facing the industry is HLB. As yet, Tucumán is considered HLB and insect free but they exist in neighbouring areas and are considered a major threat to the industry’s future. A considerable amount of work has been undertaken and currently HLB is under control. Another threat is *citrus tristeza virus* which has been kept under control.

Economic and political instability has also created many challenges. Over the past two decades there have been very high rates of inflation combined with dramatic currency fluctuations and the depreciation of the peso against the US\$ and Euro, high interest rates, dependence on foreign loans, export restrictions, energy rationing and more recently COVID-19 restrictions. Since important agrochemicals and equipment used in the sector are imported, this has led to huge price increases. These economic difficulties, as well as political instability and severe weather patterns, have combined to create major problems for Argentine lemon growers and processors. The main lemon varieties grown in Argentina are harvested from March until August.

In 2017 lemon was grown on 53,744 ha of which almost 75% was located in Tucumán province in the northwest of Argentina. The neighbouring provinces’ production areas and their lemon production were as follows:

Tucumán	39,180 ha	1,300,000 MT
Salta	8,009 ha	240,270 MT
Corrientes	2,694 ha	60,615 MT
Jujuy	1,834 ha	47,000 MT
<b>Total</b>	<b>53,744 ha</b>	<b>1,675,851 MT</b>

The area planted to lemon was forecast to remain unchanged, but replacement of old plants with new ones, in part to minimise the effects of frosts, increases the number of plants per hectare and increases yields. The future area under lemons is not expected to expand significantly in part because of competition from sugar cane and urban expansion in Tucumán province. However, new genetic planting material should improve yields and raise production. Argentina has HLB-free status with only very isolated cases of greening being detected in the provinces of Misiones and Corrientes. However, if HLB arrives, it could significantly affect yields and output levels.

Lemon production, like other fruits, faces problems relating to high taxes and logistical costs as well as a lack of access to credit. Production costs are increasing, mainly labour, inputs, energy and transport costs, both local and international. In part this is because of the uncompetitive peso currency and high annual inflation rates of 20-50%. In recent years the lifting of export taxes, combined with export rebates, has helped to reduce upward cost pressures. Fresh lemon exports have faced problems because of EU restrictions on Argentine imports because of disease and AR issues. However, Argentine fresh lemon exports to the USA have now begun along with efforts to expand fresh lemon exports to non-traditional markets.

Unlike most other countries, a large proportion of lemons is grown in Argentina for processing. Tucumán province is a long way from a port, which can make fresh fruit exports difficult. Hence the vital importance of processing which gives growers and plantation owners a very different mindset from many other producers. In contrast to other producing countries, domestic fresh lemon consumption is only 120,000 MT, and exports of fresh fruit account for approximately 245,000 MT, some 10% and 25% of production respectively. Clearly lemon is grown to service the processing industry with usually over one million MT going to the processing industry.

**Spain**  
Spain is Europe’s largest lemon producer and the largest producer

of oil; each year processing between 20-25% of output. There are approximately 48,000 ha of lemon with an estimated 14 million trees. Lemons are grown in southern Spain, predominantly in the provinces of Murcia (approximately 50% of output), Valencia (35%) and Andalusia (15%). Over the past decade production of organic lemons has been increasing, quickly reaching 7,117 ha in 2019.

Over the past 50 years Spanish lemon production has shown an upward trend, despite wide annual fluctuations. Over the period annual production has doubled and the total lemon crop in Spain in 2020/21 is forecast to be 1,290,000 MT, making it the world’s largest producer of lemons, of which some 370,000-390,000 MT (30%) will be processed.

*Fino* is a winter crop and Spain’s main variety, accounting for approximately 70% of total production. It has a spherical shape and the peel is thin and smooth. It has a high content of juice and a high acidity of juice. Cold pressed oil (CPO) has a high aldehyde content. *Verna* is a summer crop and a variety grown only in Spain. It has a thick peel, an ovoid shape and few seeds as well as a low acidity compared to *Fino*. CPO oil has a low aldehyde content.

Old trees are being replaced when needed, as the sector is profitable overall and there is now less threat from losing the land to alternative uses, such as housing. As most of the focus was already on the higher paying fresh fruit market, it is in balance and sustainable even after the EU subsidies going to processed fruit were eliminated. No untreatable diseases affect production although ARs are a growing concern. However, the industry is committed to reducing ARs and in recent years some changes have been implemented in the sector. For example, the fruit is sorted in the orchards in order to select for fresh or for processing, so more fruit goes directly from the tree to the processing plants. A second selection is made at the packing house before applying the post harvest treatments. This change in dealing with the fruit leads to a significant reduction of ARs.

Growers and exporters were reported to be integrating but processors do

not own the plantations although there are some exceptions to this general pattern. The increasing size of plantations is facilitating improved efficiency. Growers and exporters are reported to be integrating and this is shortening the distribution chain.

**Italy**  
Italy is Europe’s third largest producer of lemons, behind Turkey and Spain. Approximately 85% of Italian lemons are grown in Sicily on about 23,000 ha of land, with most of the rest grown in Calabria and a small quantity in Amalfi. The main varieties of lemons grown in Italy are *Femminello Comune* (53%), *Monachello* (10.2%), and *Zagara Bianca* (23.5%). More lemons are produced in the winter season, which runs from November until January, while the summer season is from April until July. Sicily produces about 85% of Italian lemons but production on steep hills limits mechanisation and further pushes up already relatively high labour costs. Recent estimates of Italian lemon production are as follows: 2017/18 – 570,000 MT, 2018/19 – 528,000 MT, 2019/20 – 445,000 MT, 2020/21 – 491,000 MT with an annual average over the past decade of 503,000 MT. The USDA estimates that Italy processes approximately 80,000 MT of lemon annually, substantially below Bredenberg’s 2011 estimate of 190,000 MT.

Lemon production by other European producers in 2019/20 was estimated at: Greece: 82,255 MT, Portugal 17,000 MT and Cyprus 5,000 MT.

**USA**  
California dominates US lemon production, with small quantities from Arizona. During 2019/2020 total lemon production was 27.1 million boxes (almost 1.0 million MT), of which California accounts for 25.3 million boxes. Approximately 25,000 ha are planted with lemon trees. In the USA the main focus is fresh fruit but NFC (not from concentrate) lemon juice has been growing strongly. In 2020 domestic demand for fresh lemons decreased because of COVID-19 due to the shutdown of schools, restaurants, cruise lines and other commercial food-service operations. This led to changes in the amounts of fruit intended for fresh consumption and fruit for processing.

Where previously 85-90% of the lemons were going to the fresh fruit market, this disruption in the food-service might generate the split likely to be 70% fresh fruit and 30% fruit for processing. Also puffing disease can lead to an increased proportion of lemons being processed because it makes fruit unsuitable for the fresh fruit market. However, the shape of these fruits makes them more difficult to process and leads to reduced yields. Efforts are being made to stop the spread of canker from Florida although as yet no infection of the trees has been found. Overall the growth potential of the US lemon industry is seen as negative in part because of urbanisation, high labour, land and other costs, as well as water constraints.

\*Care must be taken regarding measurement. US citrus fruit is usually measured in boxes whose net weights can vary between states. In California a box is net weight 80 lbs. (36.3 kg). A US ton is a short ton, which is equivalent to approximately 0.90 metric tonne (MT); 1.0 MT = 1,000 kg.

**Mexico**  
Mexican data combine lemon and lime but the latter dominates. Regarding lemon, Mexico is a relatively new producing origin supplying to the world market and information is very limited. Production is undertaken in Ciudad Victoria, San Luis Potosi, Colima and, since 2006 the Yucatan with the *Eureka* and *Limonera* the dominant varieties. In 2020/21 Mexico's combined lemon and lime production is forecast to expand by 6% to 2.9 million MT because of favourable weather with lemon production estimated at 135,000 MT from 9,864 ha. In their 2018 Cartagena presentations, Blum and Davalos put lemon production at 80,000 MT while Norberto Rodrigues put it at 160,000 MT and lemon oil production was estimated at 30 MT. In 2010 an estimated 85% went for processing (Bredenberg 2011). Recently lemon consumption and exports were reported up due to the greater supplies. There is reported to be a good market due to the NAFTA trade agreement and there is some growth potential. However, production faces several challenges including HLB, climatic variations and poor soil quality.

**South Africa**  
Lemon production in South Africa is relatively recent. Nevertheless, it now ranks as the world's sixth largest lemon producer and is considered

a consistent and reliable supplier. The varieties planted are mainly *Eureka* and *Lisbon*, with a small amount of *Genova* and *Limoneira* (as in Argentina). South Africa has concentrated its efforts on developing high quality fresh fruit, processing between 20-30% of production. South Africa can be very versatile when it comes to how many fresh fruits are sent for processing and so is capable of being in or out of the oil market as and when it is more commercially attractive to do so. Both the growing and the processing activities have been supported by international interests and favoured by the free trade agreement with the United States. However, the existence of citrus black spot in certain growing areas and the imposition of strict phytosanitary import controls in the EU and US markets impacts the dynamics of the sector.

In 2020/21 production of lemons/ limes was forecast to increase by 2% to 670,000 MT based on a rise in the area planted and new trees planted in the past five years coming into full production. The impact of COVID-19 on production is expected to be minimal. Lemons and limes for processing are forecast to decrease by 19% to 145,000 MT compared with 178,000 MT in 2019/20, based on increased exports and domestic consumption of fresh lemons. Lemon oil yields were estimated at 4 kg oil/ MT of fruit. Citrus black spot continues to be a problem and impacts lemon exports to the EU and USA.

**Turkey**  
Lemon production is forecast to rise 5% in 2020/21 to 1.0 million MT as a result of favourable weather. Consumption is forecast down slightly while the larger crop is expected to lead to higher exports. Despite being one of the five largest lemon producers in the world, Turkey has only a marginal processing industry. Fresh lemon exports are subsidised by the Turkish government, while the large internal market absorbs the poorer quality fruit. In addition, the varieties grown do not give very good juice, and there are problems with ARs, which are additional reasons not to process. In 2020/21 an unprecedented number of shipments of Turkish lemons was rejected by several EU countries because they contained excess levels of various ARs, which would be further concentrated if they were processed.

Although Turkey processes very few lemons it can affect lemon oil availability. For example, if Turkey has a poor crop the lack of fruit for export impacts the fresh market which in turn affects the volume of lemons available for processing. As with China, there is future potential for Turkey to become a processor and supplier of lemon oil but various issues will need to be resolved. These not only relate to ARs but also like many countries it faces water supply issues as well as climatic risks.

**Brazil**  
Brazil is the dominant global producer of oranges but lemon is a relatively recent introduction. The variety grown is *Bearss* or Sicilian lemon, developed mainly for humid climates. The majority is sold as fresh fruit but a proportion is processed by two of the large Brazilian orange processors. Lemons are produced mainly in the Limeira area with a smaller quantity in Botucatu, both northeast of São Paulo.

**China**  
China's lemon production is thought to be around 500,000 MT but quite dispersed and with limited agricultural cultivars. The focus is on fresh fruit with very limited processing but with strong growth potential.

**Israel**  
Annual lemon production in Israel is estimated at around 50,000 MT focused on fresh fruit. There is competition from other crops as well as lack of water and growth prospects are stable.

**LEGISLATIVE AND REGULATORY ISSUES**  
Due to its many possible uses, lemon oil has a wide range of legislation and regulations in many countries covering its use in foods, fragrances, cosmetics and chemical substances. A key challenge is adapting to the differing regulatory requirements between markets. Processors face the difficult task of producing high quality low residue lemon oil, complying with regulations for all substances and countries at an acceptable price.

**Agricultural Residues (ARs)**  
Over the past two decades ARs in lemon oil have become an increasingly important issue. Pesticides are used to eliminate the pests and diseases attacking the tree and the fruit – both aiming to raise productivity and improve the fruit's

visual appearance. Pressure from consumers and processors has led to reductions in the type and quantity of agricultural chemicals used – as well as being a means to lower production costs. Fungicides are used to prevent fungus development in the growing of the fruit generally, to preserve visual aesthetics and post-harvest to prolong the life of the fruit. The exception to improve yields is for the control of greasy spot. Without the control of greasy spot it could make the difference between a normal load and none at all. The issue is of greatest concern in the Yucatan, Mexico. Wax is used to make the fruit look shiny and it is convenient to have fungicide in the wax because it is convenient to have it on the exterior of the fruit and the wax protects it to enhance the efficacy.

There is an inherent conflict between fresh fruit customers and lemon oil customers regarding ARs. Fresh fruit customers often require aesthetically pleasing fruit involving the use of agrochemicals while lemon oil customers face increasingly strict specifications permitting only very low levels of ARs. As a result, those farmers and processors focusing on the fresh market have difficulty producing "clean" oil. Because of its dependence on lemon products, Argentina has been a leader in reducing the use of agrochemicals and lowering ARs. For a very long time it has reduced the use of agrochemicals in the fields and began converting packing houses so that post-harvest chemicals are applied after the sorting process. Research is being undertaken using different planting techniques and rootstocks to

increase oil yields per hectare while reducing the need for agrochemicals. For the past decade Flying Dragon rootstock has been introduced and planting densities have been increased so that the mature trees in the older plantations averaged 250-300 trees/ha whereas the newer plantations have 400-600 trees/ha.

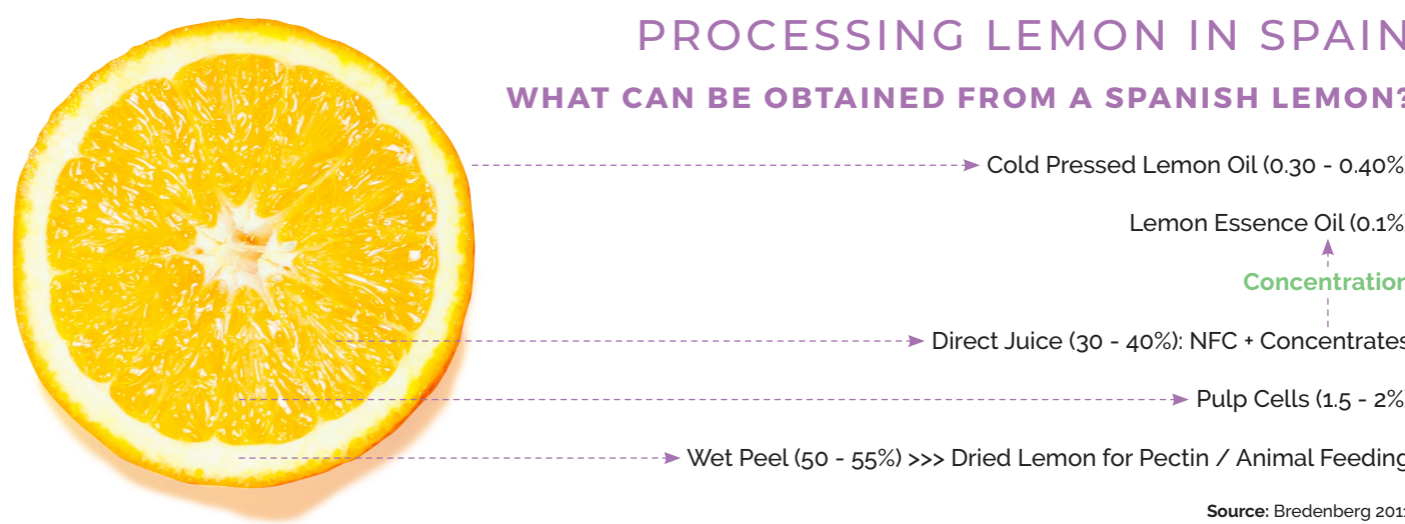
However where the concentration is on the fresh fruit market there are still issues relating to the use of substances that are not globally acceptable. In addition, some approved substances are beginning to lose their effectiveness and other compounds need to be applied. Diligent testing protocols and continued AR reduction is vital for the future of lemon oil products.

Pre-harvest most citrus fruit is treated with pesticides and also post-harvest at the pack houses once the fruit is sorted. This leads to a problem in the oil because the pesticides remain on and in the oil pores on the skin of the fruit. Often batches are tested to establish the pesticide levels which can influence the use of the oil; if the levels of pesticides are low then this can be processed for consumption or flavours, but if it is too high then it will have to be used in a fragrance application. In addition, other physical tests are undertaken to determine the quality (e.g. density, refractive index, optical rotation, smell and colour).

Legislation and regulations on pesticides have become stricter and differ between countries. Also, industry requirements are often much stricter than the applicable legislation. Considerable efforts are being made

to address these issues by different processors in each producing origin and they are working closely with growers. The fact that a lemon grower's major income is from fresh fruit sales has complicated efforts to reduce pesticide and fungicide usage. AILIMPO in Spain has been closely involved in the rational use of pesticides. There is also the related question of the impact on the final product of the amounts of residues currently found in any lemon oil as usage is proportionately very small. Blum and Davalos (2018) have argued that the reduced use of pesticides and herbicides is leading to lower productivity but the reduction is difficult to quantify. Assuming a yield of 5.5 kg oil per MT of fruit this represents a high concentration rate of ARs in the oil of approximately 166.1. They argue that organic fruit gives a low yield of about 4.1 kg of oil per MT of fruit, with only 38 MT of fruit per hectare. This compares yields of 5.5 kg oil/1 MT and 55 MT/ha with standard fruit using relatively low quantities of agrochemicals. The Italian industry argues that for several reasons ARs are less of a problem in their industry. The factors cited include: smaller growing areas, less intensive agriculture reducing the spread of disease and need to use pesticides, the rapid growth of organic farming and PGI (Protected Geographical Indicator) status.

**PROCESSING CHARACTERISTICS**  
Processing of lemon is invariably undertaken close to where lemons are produced – fresh lemons are not transported long distances and then processed.



Lemons have practically no waste. By cold pressing, some 0.30-0.55% of cold pressed (CP) oil is extracted from the skin with no thermal treatment and has a golden yellow colour. To produce one drum of CP lemon oil requires more than two large truckloads of lemons. Following the first pressing some oil remains in both the flavedo (yellow part) and albedo (white part), which can be distilled to produce "distilled lemon oil", a colourless product. The remaining skin can be dried and prepared for pectin extraction, a product used increasingly in the food and beverage industry. The preparation process requires large amounts of water and energy for drying. In addition, lemon juice is produced and concentrated, but also sold as NFC (not from concentrate). During the concentration process a small amount of aromatic oil can be recovered, known as "lemon essence oil" or "oil phase essence", as well as the aromatic water known as "lemon aroma" or "lemon water phase". Also obtained are the pulp cells of the lemons, used to increase the naturalness of drinks and in fruit preparations.

### LEMON OIL PRODUCTION

The dominant producer of lemon oil is Argentina, which processes approximately 70% of its production, although this varies annually. In recent years annual global lemon oil production has ranged between 6,500-10,000 MT. Production varies according to the volume of lemons processed, the equipment used, the maturity and variety of the fruit. If the fruit is picked at the right moment then the yield will be at a maximum. This, combined with varieties and extraction equipment usually leads to an average yield of 0.4-0.5%. Argentina accounts for about 60-70% of the global lemon oil supply with Tucumán province accounting for around 90% of Argentine supply so that "Tucumán Province produces the lemon flavour and fragrance ingredients for the world". To understand the dynamics of the market it is quite important to note the role of long term contracts between Argentinian processors and a major US beverage company.

Spain is the second largest producer but the yield is considerably lower than Argentina.

Bredenberg (2011) estimated annual average world CP lemon oil output was 7,070 MT.

More recently, AILIMPO (2018) estimated annual global CP lemon oil production at approximately 7,250 MT of which Argentina 5,000 MT (60%), Spain 980 MT (12%), USA 850 MT (10%), Italy 350 MT (4%), Mexico 300 MT (3%), South Africa 200 MT (2%), Brazil 170 MT (2%), others 400 MT (5%). It has been argued that if global lemon processing is approximately 2 million MT then lemon oil production could be as high as 8,000-10,000 MT.

The table estimates global lemon oil production based on a three-year average of estimated lemon processed from 2017/18 to 2019/20. Given the annual variations in production and hence processing there are sizeable variations in a country's lemon oil output.

It is important to recognise that over the past century there have been sizeable shifts in production. Writing in the early 1950s, Guenther said the major producers of lemon oil were southern Italy and California while "Spain, Brazil and Argentina produce lemon oil in small quantities only". Who knows but future economic, climatic and other environmental factors could lead to a continued shift in the location of production. The estimated quantity of lemon fruit processed in major lemon oil producing countries is detailed in the table.

### PROCESSING EQUIPMENT

The earliest lemon oil recovery techniques began in Italy in the late 18th century and involved hand-pressing the peel against natural sponges fixed on a terracotta basin. A mechanised system of citrus oil extraction only began at the beginning of the 20th century and new and improved systems were developed after the First World War, and led to today's well known Pelatrice, Brown, Sfumatrice, and FMC machines. Modern commercial lemon oil extractors are designed to efficiently remove oil without changing its intrinsic properties. The two alternative approaches are (i) bending the peel to force the oil out of the cell or (ii) pricking the skin and rupturing the oil cell. Now there are three major

## WORLD LEMON PROCESSING ('000 MT FRUIT PROCESSED)

Region	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	Average
Argentina	1,211	963	996	570	1,195	1,050	950	991
USA	300	191	274	169	255	202	175	224
EU (Italy, Spain, Greece etc.)	347	235	192	312	380	240	280	284
Mexico (estimated)	85	75	80	80	85	85	88	83
South Africa	82	84	58	80	77	84	84	78
Turkey	60	65	55	60	57	58	64	60
China (estimated)	10	20	30	40	50	50	55	36
Israel	2	3	3	3	3	2	2	3
Other	4	4	4	4	28	42	68	22
<b>Total</b>	<b>2,101</b>	<b>1,640</b>	<b>1,692</b>	<b>1,318</b>	<b>2,130</b>	<b>1,813</b>	<b>1,766</b>	

Source: Blum and Davalos 2018

types of equipment for processing lemons.

1. Italian oil extractors, called pelatrics or sfumatrics, available in a range of models. It is a two-step system, whereby the first rasps the outside peel (flavedo) to break the vessels containing the lemon oil, and then a centrifuge separates the solids and water from the oil. With this system the whole lemon is rasped first to extract the oil, and in a second step the juice is squeezed. In the second step, using for example the polycitrus indelicato, the fruit is cut in two and the juice is pressed out. Using this system the quality of the oil is considered higher, and fruit of all shapes and sizes can be processed.
2. American FMC equipment (now JBT), extracts the oil and juice together, but gives a lower oil yield. It was initially developed to process oranges around 1950. It punctures the outside of the skin releasing the oil, and simultaneously perforates the centre of the fruit to remove the juice and pulp. With five cups in a row and 100 hits per minute,

some 500 fruit can be processed per minute. For greatest efficiency the fruit should be the same size and shape as the cup. FMC lease rather than sell their machines. When the patent expired a Spanish copy called Excel came on to the market, which can be bought.

3. The Brown oil extractor from the USA uses a two-step system, similar to the Italian raspers but instead the peel is cut with small knives, and then in a second step the juice is extracted. It gives a higher yield of oil, which may be as much as 0.05%, but some believe the juice is of a poorer quality. Brown machines are also only leased. FMC has developed a similar oil extractor called the MORE. In Argentina, this is the most popular process and yields were quoted at about 5.5 kg of oil per metric tonne of fruit (Blum and Davalos).

Although lemon oil is a by-product it can have a significant impact on profits. Therefore, juice processors have installed state-of-the-art centrifuges and de-winterising machinery to maximise yields.

### Argentina

The increased number of lemon groves in Argentina was primarily focused on the processing industry, and although the amount going to the fresh market has increased, 65-70% is still processed. The few very large producers operating in Tucumán have invested in higher oil-yield Brown processing equipment, encouraged and supported by the stability of long-term contracts, especially with a major US beverage company.

Harvesting fruit is a costly part of the production process and mechanical harvesting is being investigated and implemented. Labour strikes in 2017 combined with the impact of COVID-19 on labour availability accelerated this development. In addition, processing equipment is being developed in an effort to increase oil yields.

### Spain

In Spain there are 48,000 ha of lemon groves, more than 3,000 growers, 100 packing houses for fresh exports and 14 citrus processors.

## ESTIMATED GLOBAL LEMON OIL PRODUCTION AVERAGE 2017/18 TO 2019/20

Country	Volume Processed (MT)*	Approximate Yield (%)	Lemon Oil (MT)	Total %
Argentina	1,330,000	0.50	6,650	68.3
Spain	272,900	0.35	995	10.2
USA	168,300	0.35	590	6.1
Italy	77,300	0.50	385	3.9
Mexico	70,000	0.45	315	3.2
South Africa	138,300	0.35	485	5.0
Brazil	50,000	0.35	175	1.8
Turkey	46,600	0.30	140	1.4
<b>Total</b>	<b>2,153,400</b>		<b>9,735</b>	<b>100</b>

Based on three-year average of estimated lemon processed

## ARGENTINA LEMON PROCESSING 2002 – 2017

	% Crop Processed	Essential Oil (MT)	Frozen Pulp (MT)	Conc. Juice (MT'000)
2002	73			53
2003	69			47
2004	75			54
2005	61			59
2006	69			60
2007	63			57
2008	68	4,000	670	47.9
2009	74	4,400	820	55
2010	68	3,250	600	43
2011	71	5,442	1,007	68
2012	73	4,344	804	54.3
2013	75	4,397	813	49.5
2014	66	2,413	452	33.7
2015	76	4,561	852	63.7
2016	68	4,840	907	66.5
2017	71	4,441	832	61.1

Source: Feder Citrus 2018 pp.11-12

The lower yield of lemon oil achieved by the Spanish processing industry is due to the fact that mostly Inline FMC and Excel citrus extractors are used. Fruit is harvested to meet demand from the fresh fruit market which does not always coincide with the optimum moment for processing. Spain's focus on high quality lemons means that fewer are available for processing. Spanish processors do not usually own plantations, but there are some exceptions.

**Italy**  
Sicily was the first area to produce lemon oil on a commercial basis beginning in the 1900s and for many years lemons were processed only to obtain oil. Eventually, the market

for juice and other derivatives also developed, allowing the cost of the raw materials to be shared by all products. As other producers arrived, Sicily found it increasingly difficult to remain competitive, in part because of its geographical position, smaller farms, a limited market for fresh fruit and the impact of disease, especially *Mal secco*, and Mediterranean fruit fly pest. Until 2008 the EU provided subsidies to compensate for higher production costs. In the early 2000s approximately two-thirds of the lemon crop was processed but this has now fallen to around a third. To compensate for the higher fruit prices some processors differentiated their quality by specialising in products for the higher priced perfumery industry

but this trend has reversed. Estimates of Italian lemon oil production diverge quite widely with current crop estimates averaging approximately 650 MT.

**USA**  
California produces 80% of US lemons, giving coastal lemon oil, while Arizona accounts for the remainder, giving desert type oil. Lemon production is dominated by the Sunkist cooperative which, together with one other large processor, makes up the lemon oil producing industry. Production for the fresh fruit market dominates production, with approximately 30% of production being processed. According to Bredenberg, the lemon groves are profitable and seem to have reached a certain equilibrium, with the Californian government promoting "slow growth" as an environmentally friendly initiative.

**Mexico**  
In collaboration with a soft drinks company, the *Eureka* variety was planted in Mexico, a large proportion of which was processed using an efficient extraction system creating good yields.

### SOCIAL AND ECONOMIC CHARACTERISTICS

The major economic and social contributions of the lemon oil sector are in relation to the employment created and the revenues generated, in many cases from exports. The revenues generated are greatly influenced by lemon oil prices which can be quite volatile. Price levels are very dependent on the size of the Argentine lemon crop – and to a lesser extent the Spanish, Italian and Turkish crops – all of which are very weather dependent. Other factors influencing price include carryover levels, currency fluctuations and particularly the value of the US dollar, as well as economic and political stability in producing and consuming countries. In addition, while some data might be available on the economic and social impact of the lemon sector in producing countries, lemon oil accounts for only a proportion of these figures.

**Argentina**  
In 2017 in the Argentine citrus industry there were 5,300 citrus growers, 330 citrus packing houses, 75 export citrus packing houses and

22 processing plants. Total direct labour employed in the sector was estimated at 91,490, so given that lemon production accounts for just less than half of total citrus production, then approximately 40,000-45,000 are directly employed in lemon production and processing. Moreover, some 58,350 transient labourers were working in the citrus sector, suggesting an estimated 25,000 transient labourers working in the lemon sector. In addition, besides family dependents, there would be many other occupations dependent on the sector for their livelihoods e.g. agricultural input and machinery suppliers, transport, storage, agricultural machinery and input suppliers.

The breakdown of the 91,490 direct permanent employment in the citrus sector was:

### Permanent Employment in Argentina Citrus Industry 2017

Primary production:	
Permanent employees	6,440
Nurseries, planting	5,460
Pruning, weeding, pre-harvest	27,900
Harvesting	25,000
<b>Packing – permanent labour</b>	<b>22,100</b>
<b>Industry – permanent labour</b>	<b>4,600</b>

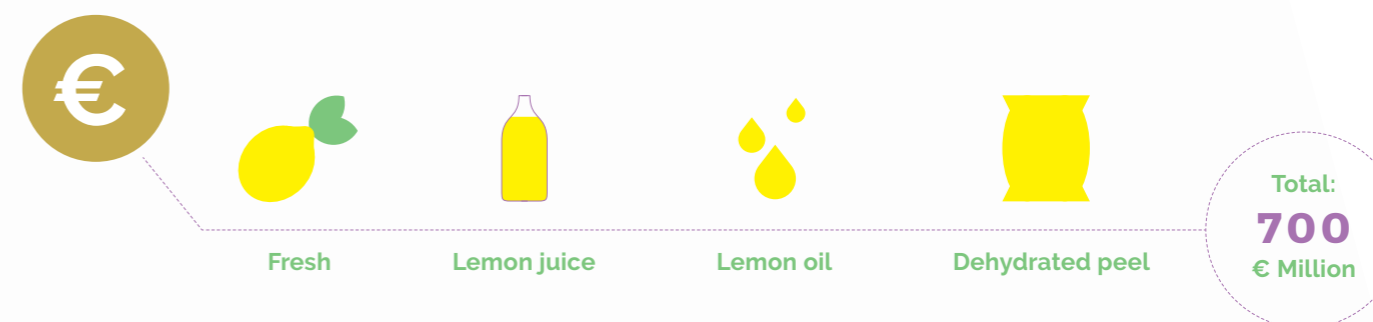
In 2017 it was estimated that the value of Argentina's citrus industry was just over US\$ 1 billion at US\$ 1,178 million. Essential oil exports, dominated by lemon oil exports, accounted for US\$ 201 million, as the table illustrates.

### Value of Argentina Citrus Industry 2017 US\$ m. (US \$1.00 = A Peso 19,00 April 2018)

	Domestic Market	Exports	Total
Fresh Fruit	378	319	697
Conc juice	33	167	200
Ess Oils		201	201
Peel		80	80
<b>Total</b>	<b>411</b>	<b>767</b>	<b>1,178</b>

**Spain**  
In Spain in 2020 the lemon sector was estimated to generate a revenue of at least €700 million from the sales of fresh lemons, juice, lemon oil and peel.

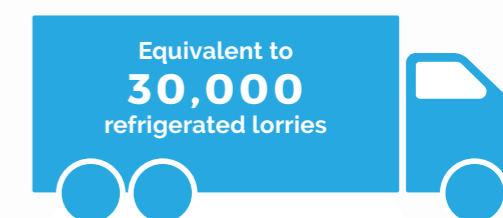
### SECTOR REVENUE



### EXPORT OF FRESH LEMONS

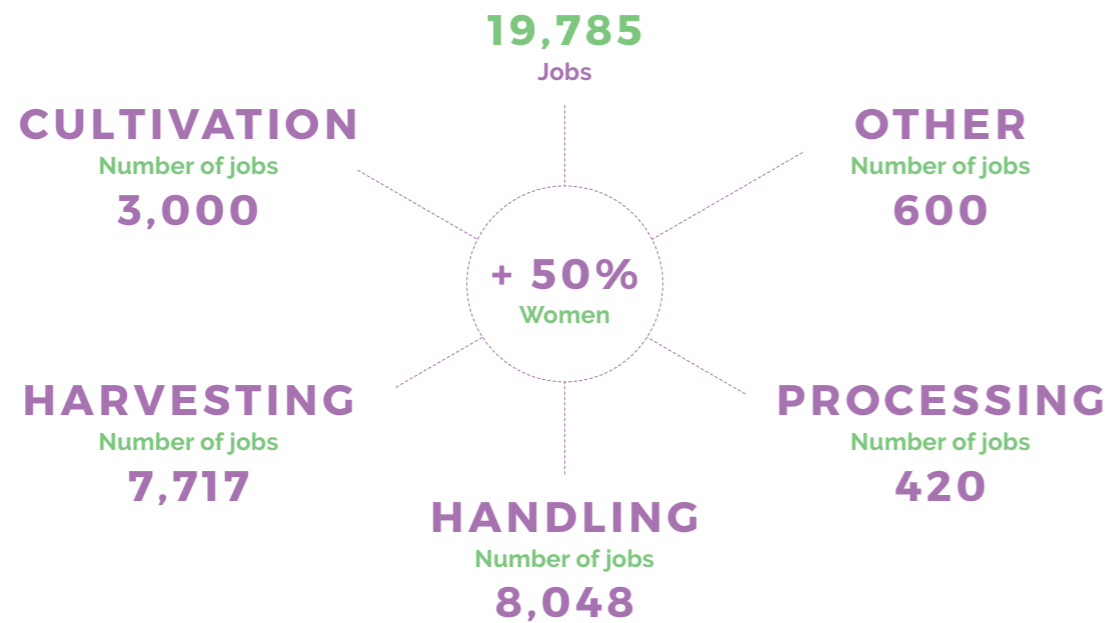
Destination	No. of markets	Volume (tonnes)	Value (€)
EU	28	561,000	472 € million
Others	62	51,000	44 € million
<b>Total</b>	<b>90</b>	<b>612,000</b>	<b>516 € million</b>

Source: AILIMPO



DIRECT EMPLOYMENT GENERATION WAS ESTIMATED AS FOLLOWS:

IMPROVING SOCIAL MANAGEMENT SYSTEM



Source: AILIMPO



The direct revenue generated was estimated as follows:

Packaging	€82 million
Domestic logistics	€82 million
Energy consumption	€15 million
Pruning – handling and cultivation	€20 million
International logistics	€86 million
Inputs	€15 million

ENVIRONMENTAL AND SUSTAINABILITY INITIATIVES

Alongside the direct economic and social benefits generated by the lemon sector there are also important environmental and sustainability contributions. Increasingly initiatives are being undertaken in the sector

facilitating greater sustainability and helping combat climate change. Spain has been undertaking a range of sustainability initiatives covering environmental, social and economic aspects summarised in the following diagram. Initiatives on the environmental side include efforts to reduce the use of pesticides and fertilisers and updating the tree census.

SUSTAINABILITY: MULTIPLE FOCUS

SPANISH LEMON® (FRESH + PROCESSED)

= 3 PILLARS



Source: AILIMPO

Unfortunately data on other major producers, e.g. USA, Italy, South Africa, Mexico as well as other producers, are not available. But a very approximate estimate based on pro-rata Argentine and Spanish data would suggest that the lemon industries in these countries generate employment of at least 280,000 people and revenues in excess of US\$ 2 billion. Obviously the proportion directly attributable to lemon oil would be substantially smaller, but nevertheless still substantial.

Other environmental policy initiatives include commitments to reduce scarce water usage through more efficient utilisation as well as efforts at CO<sub>2</sub> capture and the achievement of a positive CO<sub>2</sub> balance.

The Spanish lemon sector contributes actively to the fight against climate change by being a real CO<sub>2</sub> sink. In early 2021, AILIMPO provided carbon footprint data for the lemon sector showing that it annually captures more than 300,000 MT of CO<sub>2</sub>.

Measurements of CO<sub>2</sub> emissions were taken along the value chain from growing, transportation, packaging and processing. Lemon groves have a high capacity to capture CO<sub>2</sub> through carbon fixation, and AILIMPO estimated the crop captures the equivalent of 360,550 MT each year. The high CO<sub>2</sub> fixation figures are due to the implementation of increasingly sustainable practices by producers (e.g. low soil tillage, use of residues and localised irrigation systems leading to reduced water consumption, growth of organic cultivation, use of renewable energy and electric vehicles).

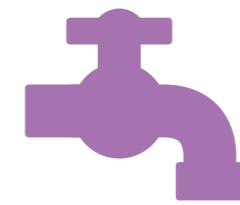
Currently, the sector emits an estimated 49,300 MT of CO<sub>2</sub> a year – 18,122 MT in transportation, 19,705 MT at packing house level and 11,472 MT in processing plants. This gives a net CO<sub>2</sub> saving of 311,250 MT a year as the illustration right illustrates.

CONCLUSIONS

Lemon production and processing, including the production of lemon oil, make vital economic, social and environmental contributions to the lemon producing regions of lemon producing countries, particularly Tucumán (Argentina), Sicily (Italy) and Murcia (Spain). The industry provides livelihoods for tens of thousands of people as well as generating millions of US\$ in sales and export revenues. In addition, the sector makes substantial environmental contributions, and initiatives are being adopted to combat climate change by capturing CO<sub>2</sub> as well as providing other environmental benefits.

Over the past century the lemon industry, including lemon oil, has witnessed substantial changes and

WATER NEEDS AND EFFICIENT USE



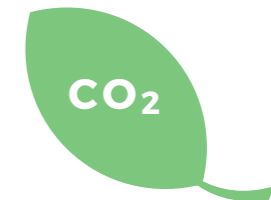
**232.4** hm<sub>3</sub>/year

COMMITMENT WITH CSR AND SUSTAINABILITY POLICIES



POSITIVE CO<sub>2</sub> BALANCE: NET CO<sub>2</sub> CAPTURE

Positive CO<sub>2</sub> Balance



**304,840**

MT of CO<sub>2</sub> captured — Equivalent to — 1 year's diesel consumption of 140,000 cars driving 20,000 km/year

Source: AILIMPO

CARBON FOOTPRINT OF THE LEMON SECTOR IN SPAIN



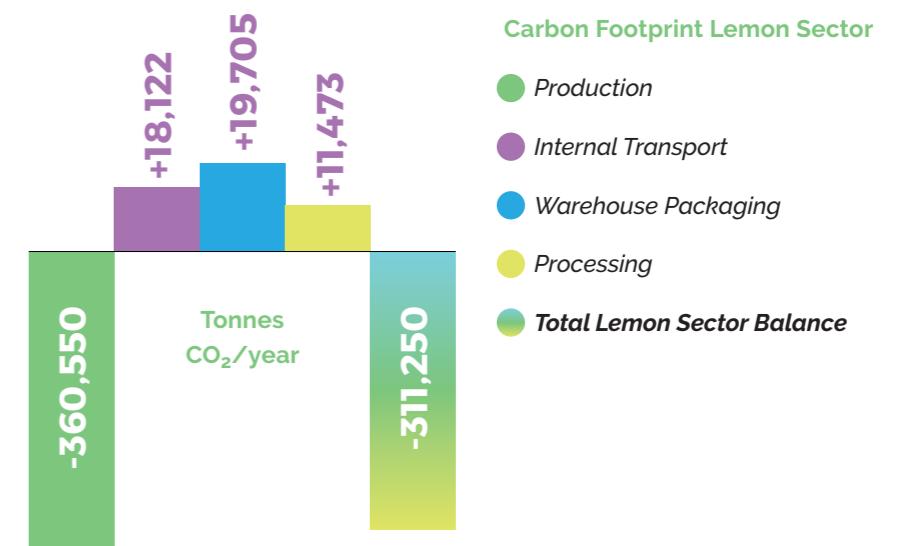
Addressing United Nations sustainable development goal (SDG) 13, to take urgent action to combat climate change and its effects



Spanish Lemon figures

**45,832** hectares

**1,208,159** tonnes



Source: AILIMPO

these are likely to continue, both with regard to production and along the value chain. The industry faces many challenges and future trends are difficult to predict. Some of the major lemon producers and processors, particularly in the EU and USA, face substantial pressure on land availability, combined with high labour and other costs. Currently Argentina, the largest producer, faces a range of challenges. Meanwhile, in China the industry is reported to be growing and thriving but the main focus in China is to grow fresh fruit for the domestic market.

The industry faces a range of challenges, including:

- Production is largely dependent on climatic conditions which are often outside growers' control, although some initiatives can reduce the impact of weather, e.g. irrigation.
- Because of the focus on fresh fruit, pesticide residues have become a major concern as consumers become more quality conscious.
- Investment requirements are high, not only because of lemon's long gestation period before yielding fruit, and hence revenues, but also because of high capital costs (e.g. land, equipment for harvesting and processing) and input costs (e.g. labour, agrochemicals).
- Political and economic instability, particularly in the world's major lemon producing country.
- Currency variability and price volatility for both the fresh fruit and oil can create difficulties.
- Citrus fruit diseases especially HLB – greening, but also canker, black spot, and false codling moth.
- Considerable competition from a range of producers and countries, with considerable variations in efficiency and productivity along the different supply and value chains. Some existing producers face pressures from land development, competitive crops, environmental issues and input costs and may struggle to remain competitive. There are potential new suppliers e.g. China, India.

Nevertheless, on the positive side, the increasing demand for healthy, natural "green" products should facilitate growing consumption of lemon products including lemon oil.

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