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IFEAT WORLD

INTERNATIONAL FEDERATION OF ESSENTIAL OILS & AROMA TRADES

SEPTEMBER 2021

ONLINE CONFERENCE PROGRAMME

ROSEWOOD

SOCIO-ECONOMIC REPORT ON LEMON

MY FAVOURITE: DISTILLED KEY LIME OIL

IFEAT ONLINE CONFERENCE
9-10 NOVEMBER 2021
KEEPING THE INDUSTRY TOGETHER

WELCOME TO A CITRUS THEMED EXTENDED ISSUE OF IFEATWORLD

I hope you enjoy reading this larger edition of your IFEAT magazine and can set aside some time to read and enjoy the in-depth articles.

There is an interview between IFEAT Executive Committee member Kim Bleimann, Gill Bleimann and Ilko Minev, an author and exporter of rosewood in the Amazon. Ilko talks about the history of rosewood in the Amazon and his relationship with "Bois de Rose" (*Aniba rosaeodora*), the rare and beautiful rosewood tree native to South America.

Following the citrus theme, we have an extensive Socio-Economic Report on lemon oil written by Dr. Peter Greenhalgh on behalf of the Socio-Economic Committee. The in-depth report discusses the growth, production and processing of the main varieties of lemon grown around the world. It also looks at the key challenges facing lemon production along with the legislative and regulatory issues covering its use in foods, fragrances, cosmetics and chemical substances. The socio-economic and environmental impact of the lemon sector is also reviewed.

Continuing with the citrus theme, the "My Favourite" article on page 32 is written by Hugo Bovill. Hugo was the first author in the "My Favourite" series and this time he writes about his second favourite, Key lime oil.

If you haven't already registered for the IFEAT 2021 Online Conference, you still have time. A good number of delegates and exhibitors have already registered and have been using the Whova platform to have video meetings and chat with other delegates since registration opened in July. The platform will remain open for delegates to continue having meetings until December. There will be two days of live Conference presentations and panel discussions over 9th and 10th November and you can read more about the full programme on pages 4 to 7.

IFEAT would like to thank the authors for their editorial contributions to this edition of IFEATWORLD.

If you would like to contribute editorial, or write a "My Favourite" article, please contact the editor, Tina Hotchin, by email at: ifeatworld@ifeat.org

Tina Hotchin
Editor

IFEAT 2021

ONLINE CONFERENCE PROGRAMME

In the absence of our annual in-person Conference, IFEAT wanted to bring together its members for another online networking and education event. The Conference platform, Whova - which is familiar with in-person delegates from the three past IFEAT Conferences - was selected for the online Conference and allows greater functionality and more opportunities for networking and meeting with other delegates, exhibitors and sponsors. From registration until 30 days after the live event dates, registered participants can make video calls with others, interact via the community board and chat with other attendees, exhibitors and sponsors. Exhibitors and sponsors can show videos, have live presentations and upload unlimited documents in their virtual booth area.

The four main web platform and mobile app sponsorships sold within the first two days of registration being open, we have a number of online exhibitors, and ticket sales are increasing steadily. The platform sponsors are A. Fakhry & Co., The Lebermuth Company, Mane Kancor Ingredients Private Limited and Moellhausen S.P.A.

THE PROGRAMME

Times are in GMT

Day One

The first of two days of live programme sessions will begin with a half hour speed networking session where up to 500 participants can take a "virtual" seat at one of the online tables of four for a quick-fire, five minute networking session. Each person is then shuffled and taken to another table. This should be a fun way to get to know other participants on the platform. Four of these sessions will take place over the two days at the start and end of each day of the programme to allow speed networking to take place in all time zones.

The main Conference programme sessions will be opened at 10:00 am on 9th November with a welcome speech by Hussein Fakhry, IFEAT's Executive Committee Chairman. The venue for the IFEAT 2022 Vancouver Conference will also be announced following Hussein's presentation.

The first presentation will be given by Martin Hitziger from CITES (the Convention on International Trade in Endangered Species of Wild Flora and Fauna). The presentation will describe CITES' relevance for the essential oil industry. Martin will point out species and products of particular relevance to the essential oil industry that are regulated under CITES and administrative processes used to implement the regulatory processes. It will familiarise the audience with ongoing policy processes to further develop CITES regulations in the future, opportunities and requirements for contributing to such processes, and available resources to access further information. A Q&A will follow.

MARTIN HITZIGER

Environmental Scientist

Martin Hitziger is an environmental scientist and a decision scientist. As associated Plant Species Officer in the Scientific Services Unit of the CITES Secretariat, he supports the implementation of CITES mandates and processes related to medicinal and aromatic plant species, such as African cherry, agarwood, boswellia, and orchids. Previously, he held research positions in the fields of medicinal plant species, intercultural public health, and transdisciplinary north-south collaboration at the University of Zurich and ETH Zurich. Martin has fieldwork and intercultural facilitation experience in Colombia, Ecuador, French Guyana, Guatemala, India, Chad and Tanzania.

The first of four panel discussions, entitled ***Citrus and Mints: Concerns of Small and Large Farming for the Future of Essential Oils***, is scheduled to begin at 12:00 GMT. This will be moderated by IFEAT's Communications Committee Chair, Dominique Roques from Firmenich.

DOMINIQUE ROQUES

Firmenich

Citrus and mint are by far the largest produced essential oils used by a variety of industries. They are widely used in the fragrance and flavour industries but they are also used in pharmaceuticals, aromatherapy, etc. From a volume perspective, the fruits and plants of these oils are grown primarily by large scale agriculture for citrus and by small farming for mints, but there are also examples of the opposite (American mints and European citrus). As such, the reasons behind this are of high importance when looking at the future of essential oil production for both citrus and mint.

The panel will discuss and explain this highly contrasted situation and panellists will share opinions on how it could evolve in the future. The panel will also look at the pros and cons of each type of supply chain, from technical, economic and social perspectives.

The second panel discussion, entitled ***Agricultural Residues in Naturals: Scientific and Regulatory Landscape***, will take place later the same day and will be moderated by Jonathan Bonello, IFEAT's Chief Scientific Officer.

JONATHAN BONELLO

IFEAT's Chief Scientific Officer

The topic of contaminants, and agricultural residues, is not new but one of increasing importance to our industry as recently experienced in the European Union, for example, the ban on the use of chlorpyrifos and chlorpyrifos-methyl among other commonly used Plant Protection Products (PPPs) at relatively short notice.

Indeed, the European debate on PPPs is becoming more contentious and the European Commission is reviewing its Sustainable Use of Pesticides Directive, as part of its flagship Green Deal initiative launched in December 2020. Similar regulatory initiatives are already ongoing in other regions of the world as well, some of which may take inspiration from the European approach.

In this context, some of the topics that will be addressed during this panel discussion will include:

- In a constantly evolving regulatory framework on maximum residue levels (MRLs) and often very low contaminant concentrations, what are the technical challenges in developing accurate and reproducible analytical protocols for identifying and quantifying PPPs in agricultural produce and downstream products?
- How can regional differences in legislation be managed across a global value chain? What is the impact on trade and availability of essential oils and associated natural extracts?
- How can such regulatory changes be anticipated so that the necessary facts and data are collected and made available in time for advocacy efforts with competent authorities?
- Can farmers and producers stay in business without the use of PPPs? Can they continue to increase output of essential oils and related natural products to satisfy growing global demand without the use of PPPs, while at the same time reducing the impact of agriculture on the environment, climate change, water demand and biodiversity?
- Do PPPs need to be part of the equation, as part of intelligent anti-pest management systems and alongside new technology?
- What challenges do farmers and producers face in terms of keeping up with and adapting to the regulatory requirements in various regions of the world?
- How are producers of PPPs adapting their product pipelines and R&D efforts to the evolving regulatory landscape as well as product restrictions and bans?
- What alternatives are or may eventually be available as replacements to synthetic PPPs?

The panellists, all seasoned experts across the value chain, will share their insights, perspectives, and vision on the short-, medium- and longer-term aspects of this complex issue.

Tuesday's final session will be a presentation entitled ***Materials Metabolism: Green Chemistry for a Circular Economy*** by Dr. John C. Warner.

As we design products to be more sustainable and to fit within a circular economy we are best served to recognise and learn from patterns within nature. There exists a circular pendulum that swings between the natural world of stable ecosystems and the human built world of products. Centrally located between these two systems exists the domain of the "materials metabolism", the molecular mechanistic foundation of the assembly and disassembly of molecules and materials. Nature typically carries out the deconstruction and construction of materials through catabolism and anabolism, performing both metabolic processes synchronously. Human industrial design has evolved to perform the synthesis and breakdown processes in spatially and temporarily separate spaces. The principles of green chemistry provide a logical framework to design products within the materials metabolism. This presentation will discuss the general concept of the materials metabolism and provide real world green chemistry examples.

John is a senior vice president of chemistry and distinguished research fellow at the Zymergen Corporation where he is helping to design and create commercial technologies inspired from nature consistent with the principles of green chemistry. With over 300 patents, he has invented solutions for dozens of multinational corporations. His inventions have also served as the basis for several new companies.

DR JOHN C WARNER

Zymergen Corporation

He is one of the co-founders of the field of green chemistry and has over 100 publications providing foundational work in the fields of noncovalent derivatization, polymer photochemistry, metal oxide semiconductors and synthetic organic chemistry.

IFEAT 2021 ONLINE CONFERENCE PROGRAMME

The first day of the programme will end with another speed networking session.

Day Two

After a third speed networking session, day two will begin at 10am with a roundtable discussion entitled ***Traceability: Market Expectations and Business Reality: Where do we Stand?*** The roundtable will be moderated by IFEAT's Vice Chair of the Scientific, Education and Socio-Economic Committees, and Tristar Coordinator, Geemon Korah of Mane Kancor Ingredients Private Limited.

GEEMON KORAH
Mane Kancor Ingredients

Following this, the third panel discussion entitled ***The Future of Sustainable Natural Products and Biotechnology: Expectations and Reality*** will be moderated by IFEAT's Scientific Committee Chair, Alain Frix from Allchemix bv.

ALAIN FRIX
Allchemix bv

Sustainability is a concept that is present in many current discussions and plays a key role in future investment decisions. Sustainability can be defined as a complex and dynamic balance between economic, environmental and social aspects. A broad concept that includes competing objectives. This panel discussion, we will evaluate the sustainability expectations of essential oils and biotech products. Many interrelated parameters define a sustainable product (renewability, biodegradability, carbon footprint, toxicity, water management, rural economy, fair trade, farmers' livelihoods, extraction technology, plant protection, soil degradation, biodiversity preservation, transportation, green chemistry, etc.).

The panel aims to highlight the key parameters of sustainability, those that will be increasingly demanded by our F&F industry. Producers of essential oils and/or aromatic molecules need guidance in prioritising their sustainability investments. In addition, sustainable products will need to be available in significant quantities. The panellists will discuss the current and future availability of essential oils and biotech products. How will they coexist? What will be their role in the renewable product mix? What can we realistically expect?

It also brings to the fore the commitment needed by the trade and end users to support sustainable initiatives. These are more likely than not loss making in the initial years. How much will the channels accommodate these initiatives until it bears fruit?

Educational Session - A Profile of Cardamom

IFEAT is expanding its educational programme through an Online Learning Series (OLS) and the 2021 Online Conference will see the launch of its first OLS course with a 90-minute session on cardamom oil. The session will be free for delegates registered at the Online Conference.

The cardamom session will be made up of three components:

- Presentations on Guatemala and India's cardamom sectors, including short videos
- Jill Costa, Chief Perfumer from The Lebermuth Company and flavourist John Wright will discuss samples of cardamom oil from these major origins
- A live panel discussion of the presentations, moderated by IFEAT Study Tour Chair, John Nechupadom of Plant Lipids, will then take place, followed by a live Q&A

JILL COSTA
The Lebermuth Company

JOHN WRIGHT
Flavourist

JOHN NECHUPADOM
Plant Lipids

The final presentation of the IFEAT 2021 Online Conference is entitled ***EU Chemicals Strategy for Sustainability – a Paradigm Shift in EU Chemicals Management*** and will be presented by Sylvie Lemoine, Executive Director of Product Stewardship at Cefic (The European Chemical Industry Council).

Sylvie is responsible for the key chemical legislation topics, including REACH, CLP, an EU framework for endocrine disruptors, sustainable products policy and now, the Chemicals Strategy for Sustainability. She is a seasoned government affairs professional with more than fifteen years of experience in EU chemicals legislation and holds a PhD in Organic Chemistry from the Louis Pasteur University in Strasbourg, France. Sylvie started her career in ExxonMobil Chemical.

SYLVIE LEMOINE
Cefic (The European Chemical Industry Council)

Day two will end with the last of four speed networking sessions.

A number of breaks have been scheduled throughout both days to allow for delegates to meet with other delegates and visit the sponsor and exhibitor booths.

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STEPHEN PISANO

LEAVES THE IFEAT EXECUTIVE COMMITTEE

Stephen Pisano, Vice Chair (VC) of the IFEAT Executive Committee (EC), resigned as an IFEAT Director on 1st September 2021.

Stephen was elected to the EC in 2016 at the Dubai Conference, becoming VC in 2019. Also in 2019, he was Co-Chair for the Bali Conference alongside Ravi Sanganeria. From 2017 to 2020 Stephen was Chair of the Study Tour Sub-Committee and Chair of the Future Destinations Sub-Committee from 2019. He also sat on the Staff Management Sub-Committee, Nominating Sub-Committee, Steering and Finance Committees in VC capacity, and was a member of the Education Committee.

IFEAT is pleased to announce that Executive Committee member Catherine Kuit-Crowley will step into the first Vice Chair position.

In his letter of resignation, Stephen said; *"Of course, I will remain a big supporter of IFEAT and the Executive Committee. I am available to help Catherine transition into her role as first Vice Chair. Going forward I will be happy to participate and assist the Committees from an external role where I can be of the most help."*

Stephen will be greatly missed by the EC, staff and consultants. Chair of the IFEAT EC, Hussein Fakhry, said; *"Stephen has been a mainstay of my chairmanship. Always available, of great insight, composed, helping whenever and wherever he thought he was needed or when I needed him to enrich a debate or help resolve judiciously an issue. I will greatly miss him, but I also know - and the EC as a whole - that I can count on him anytime his input will be felt and needed. I am rest assured and confident that the team he formed with Catherine Kuit-Crowley (IFEAT's 2nd Vice Chair) will allow Catherine to move 'into his shoes' in a seamless manner."*

ROSEWOOD

AN INTERVIEW WITH KIM BLEIMANN, GILLIAN BLEIMANN AND ILKO MINEV

BY SEAN FARLEY, CONTENT WRITER AT BERJÉ INC.

Rosewood, also known as Bois de Rose (*Aniba rosaeodora*), is a rare and beautiful tree native to South America. The name Bois de Rose quite literally means "wood of rose," a name that was bestowed upon the tree by French explorers during their 18th century expeditions into the Amazon. Originally used in tribal medicines and ceremonies by Amazon natives, rosewood quickly became a phenomenon within the international market, rising to prominence among carpenters and craftsmen. The beautiful tonewood of the tree was used in everything from musical instruments to high-end furniture, spreading throughout a remarkable number of industries. For fragrance applications, the leaves and wood shavings were heavily desired for their incredibly high natural linalool content. Throughout the 19th and 20th centuries, Bois de Rose earned a new name: "ivory of the Amazon" due to both its rarity and its expense. Logging operations grew larger, trees were cut faster than they could be planted, and soon there was very little Bois de Rose material left to be extracted from the rainforest. Rosewood nearly became extinct until a series of environmental restrictions were placed on the harvesting of the tree during the 1990s, ceasing all production of rosewood within the Amazon.

Rosewood remained scarce in the international market for decades until recent operations discovered a more sustainable method of farming the trees. Rather than being extracted en masse from the wilds of the Amazon, Bois de Rose now finds itself among small-scale "rainforest plantations", growing and harvesting plant material through renewable methodology. This new, highly sustainable farming tactic has started to put rosewood back on the map for high-class perfumers around the world. To discuss this new resurgence of rosewood, IFEAT Executive Committee member/ Berjé's CEO, Kim Bleimann, along with Berjé's Executive VP, Gillian Bleimann, sat down with Ilko Minev, an author actively involved in one such Bois de Rose operation. In this interview, the group discuss Ilko's history with the Amazon, the region's troubled legacy, and the future of rosewood oil production.

THE INTERVIEW

Kim Bleimann: To start, would you mind telling us a little bit about yourself and what your relationship is with the region, Ilko? How did you end up doing business in the Amazon?

Ilko Minev: Well I first came into the business around 25 years ago, first as a trader and exporter, then later as a counsellor to Zanoni Magaldi, who owns the most important rosewood plantation. I was originally born in communist Bulgaria, where I studied as a student and became a political dissident. I was lucky enough to escape; first to Belgium, then to Brazil. I went to the Amazon, which is where I've lived ever since, and I am very much involved with the region in all possible aspects: business, culture, and nature. The nature is one I especially appreciate and like to actively participate in, especially when it comes to preserving the Amazon rainforest. Nowadays, I consider myself "caboclo" as an inhabitant of the Amazon, which is a name [which is] a colourful mixture of European, Africans, and Native Indians call themselves [this]. In Bulgaria, I am mostly known for my writing, rather than my business.

Gillian Bleimann: Wow, so you're a man of two lives; one lives in the jungle and the other is an author! I guess that's a good segue into explaining how the Magaldi family first arrived in Brazil and started to produce rosewood. How did that all begin?

IM: Ah, so the Magaldi family was originally from Italy and Mr. Paolo Magaldi arrived in Brazil in the 1890s. When he first arrived, he went to São Paulo, but he was a young man who wanted a little more excitement, so he left for the Amazon. Not only the Amazon, but he went to Maués, which is a very remote place, even today. Imagine what it was like back near the end of the 19th century! So anyway, he started different small businesses, he married and had a son named Francisco Magaldi, who is the grandfather of Carlos Magaldi; present CEO of the Magaldi Company. In the beginning, the family worked with guarana, which is used in popular Brazilian soft drinks.

However, in the 1950s, the Magaldi family decided to go into the rosewood business. At first they started with a small operation located in a distant region of the Amazon, even further away from Maués, hidden away in the jungle. Having such a remote location was supposed to be an advantage; you could be close to where the trees were planted. The idea was not wrong, but the experience showed that it was much better to be close to an urban centre where you have people that can be hired to work at any moment. Funnily, they started their first plantation in the early 1960s, and at the time this was considered "revolutionary". There was a huge quantity of rosewood trees available in the region and

ILKO MINEV
author and exporter of rosewood based in the Amazon

KIM BLEIMANN
Committee member and owner of Berjé Inc.

GILLIAN BLEIMANN
Executive Vice President of Berjé Inc.

the event turned out to be really visionary. Unfortunately, they were not successful for different reasons, mainly because it is a tricky business to get into especially when you only get to visit the operation from time to time. They had no success planting rosewood in this location and moved the distillery to a place that was closer to Maués, in an area that had been deforested beforehand. Until then, the land would serve as a place to raise cattle.

The cattle also turned out to be a bad business venture, so they eventually decided to try their luck at a second rosewood plantation. They planted about 2,500 trees, which was quite an effort since seeds were not readily available. Raising the seedlings of rosewood trees is a very complex activity, and a lot of knowledge needs to be obtained by listening to small local farmers. The Amazonian sun is very strong, and new plantations require banana leaves to protect them from solar damage, especially during the long hours of the day. For different reasons the second investment in rosewood turned out to be unsuccessful as well. By the end of the 1970s and in the early 1980s, a friend and important customer and exporter of rosewood, Samuel Benchimol, convinced them to try a third time. Only this time, they would get some scientific help from some Brazilian universities. Rather than just a side experiment, the family made a real investment into rosewood production, testing out everything from shade quality to distance between seedlings, doing everything they could to ensure the harvest was good. In the early 1990s, the plantation had its first harvest, and it was finally successful!

At the time, one of the most important scientists in this field, Professor Lauro Barata, had determined that growers should "never sacrifice a tree". Instead, plantation owners had to prune the trees regularly, focusing on the trees that were already better developed. When they started doing this experiment on the plantation, they discovered that as they were pruning, the trees were growing better and getting green faster. This was very important for the business because the family had now interrupted the normal way of doing things. Before this discovery, plantations just planted and cut the trees. If they were pruned instead, the rosewood grew much faster, so it was a much better idea to spare the tree and explore its other parts for distillation. The tree was almost treated like a cow: give it time to grow and it produces oil that is even stronger.

KB: So how has this breakthrough affected rosewood in modern markets? Did this change in the process happen around the same time that the Tropical Plant Institute started its distillation of leaves and twigs?

IM: Well this happened a little later, and this is why I think that the rosewood project started to become economically interesting only around 10 years ago. Things have reached a point now where the market is really becoming interesting; even though the price of material has increased unbelievably over the last 10 to 15 years, Magaldi took very little profit out of this. Almost all of that money has been reinvested into rosewood plantations instead. If you take a look today, you will see just how unique this product is for the Amazon. It is very promising; I haven't even retired yet just because I want to see this work! I've been here since the beginning of this industry and it's a little bit of a creation of mine.

It's kind of a pity though; I know the difficulty you have, and we have the same difficulty here, with all the red tape surrounding the product. However, the industries in the F&F sector need a constant supply, and the concept of "just in time" does not work with the way things are currently set up. I recognise that, but I also believe that we will succeed in convincing the bureaucrats that if we don't allow the Amazon to produce something, the rainforest is lost. The only possible way to save the Amazon jungle is to let it produce something for the people who live there, and produce something without causing people to set it on fire or cut down its trees. The trees need to be more valuable standing up than laying down. In this aspect, the project of Magaldi is something very valuable indeed. It just takes a little more effort to increase the current flow and be more constant in its production.

GB: Well I think that's why we've been so good in our partnership; the logistical challenges and issues with reliability of supply are an issue for the industry that we've been working

ROSEWOOD SEEDLINGS IN PREPARATION
the Magaldi plantation maintains thousands of trees across multiple planting regions

towards fixing. We, in conjunction with Berjé, have tried to remedy that and build up some stocks here that we can keep for the industry. Have you supported the Amazon through any other actions? I love how you said we need to make the trees "more valuable standing up".

IM: Well it's true! And I am lucky, because in the Amazon state, which is my region, the native forest is 97% preserved. The other Amazonian states have suffered an invasion of people, plantations, and damaged soil. People go to the jungle, plant for a few years, then abandon it. It is a great pity. But we are trying to help through more actions than just rosewood. Even my kids are involved in other safe plantation efforts. The whole world wants to help the Amazon, but sometimes they don't help fight in the right way. This fight will only be successful if we can convince local people it is better for them to keep the forest alive and exploit it in sustainable ways. The process is starting to happen, but it's too slow.

Well-intentioned people and NGOs insist on sending the police or the army, but this is a partisan war and we should understand that in the long history of the world no army has ever won a partisan war. The moment you turn your back, deforestation happens. All it takes is a little more understanding and a little more investing, because right now the "wish to help" is not sufficient. You need to have a willingness to learn how. Just like how Magaldi tried to plant rosewood three times and only succeeded on the third time after learning from the researchers, so too will people need to learn patience and understanding from the experts of today.

KB: Either patience or stubbornness; one of the two! Ilko, can you explain a little bit about the deforestation? What we hear in the press over here is that it's mainly caused by outside interests and logging companies going in and doing all this deforestation. You're saying it's more locally driven by the people who live there? That's totally the opposite of what we usually hear outside the region.

IM: Yes, yes, let me explain more so you might understand it a bit better. So, if there were big companies involved in Amazon deforestation, and I'm not saying that there aren't any but they are relatively few, and they were sending their big machines, tractors, equipment to cut the wood and move it, they wouldn't have to burn anything. When you burn the trees, it shows up on satellites and lets everyone know you are burning something. The burning is a local culture; even the Indians burn! If you live in a place with many leaves that are constantly falling down, you need to clear your land before you can start planting whatever you want. So a bigger part of the forest burns, more than 60-70%, are burned by local people. There is certainly some influence from outside companies and people investing in soy plantations, but even those people are coming to the conclusion that the soil is very poor in most places. Once you cut the trees, you have good soil for around two to three years, but after that you will spend too much to keep it too productive. Then it will be abandoned.

On the other hand, the Amazon is a massive piece of land, 90% of which is forest. The other 10% is prairies; I have been in several places where you look around and can't even see a tree! These are places in which people could plant crops for various purposes

THE MAGALDI ROSEWOOD PLANTATION
a frequent spot visited by industry tourists and international buyers interested in the process of oil extraction

ROSEWOOD SEEDLINGS ARE EXTREMELY DELICATE
they require careful farming methods to grow successfully; the leaves of young rosewood trees are easily damaged by intense sunlight

and have it work out well. However, the problem is that the entire Amazon is regulated. When you tell people you want to plant something in the Amazon, their immediate reaction is; "No, don't touch it!". There are 25 million people that live near the Amazon and all of them need occupations. They have children, families, and homes, and the moment they have no money to eat, they will burn, they will cut, they will do whatever they need to do to survive. We need to find something that is useful for them to do and explain to them how they can do better if they leave the trees standing. From my experience, they understand it after a while, but it is still a challenge. In this aspect, the project of Magaldi is very valuable; they do not touch a single piece of wood from the wild jungle. Instead, it is all organic and all harvested from the controlled plantations.

KB: This is all good info, especially with the extra emphasis on organic material that is sustainable. Can you tell us a little bit more about the verification process with CITES? Stuff about the number of trees, how long that happens, etc.

IM: Well, in our plantation every tree has a number. We GPS their coordinates and it is a lot of work! Locally IBAMA, the Brazilian environmental agency, represents CITES. They come every now and then to accompany us in our work. We prune the rosewood trees during the summer, after the rainy period that starts around November and goes until June. After that, pruning is scheduled to begin, but before that can start, we have people come in from CITES. They issue the authorisation to cut a certain quantity that they calculate to be sustainable. After that, we decide which of our 13 areas will be exploited. We never exploit the same area twice in a row; we typically use three to four areas per year and give them a year of rest between harvests. The idea is to eventually use more, up to five though this has not yet happened. It's a slow learning process and Magaldi needs to check that everything works before the process is changed. No jumping ahead!

Each tree that is planned to be pruned is marked beforehand. Once the raw material is pruned, it is immediately taken to the distillery. This is very close by, usually only 400 to 500 metres from where the material is cut. Then they let the material rest over three to five days, allowing it to dry out before it is cut and pruned again for distillation.

KB: So does CITES come back and monitor the distillation process too?

IM: Oh yes! They definitely come for this, and this is one of the problems. You inform them that you have sold material and are ready to begin distillation; all you need is the final authorisation. But they often say that they don't have the budget for someone to travel right now. One time, around 15 years ago, I offered to pay the cost for them! They were not happy; let's just say that never again will I offer to do something like that in my life! To them, it sounded like corruption. Even though Magaldi has a long history here, they've never had a problem with the environmental agencies, especially working with such a sensitive product that has so many regulations. It is a very complicated region that requires a lot of patience.

KB: And do the people who come for regulation change every year? Are

CARLOS MAGALDI
the Magaldi family has been operating in this region of the Amazon since the late 19th century; Carlos Magaldi, is the latest generational owner of the current rosewood plantation

you at least dealing with the same people every time? Or is it normally just some 24-year-old kid?

IM: Well, it is always a problem when a new one comes. At first, they always believe that I'm doing something wrong, and I have to show them! After around half a year, that attitude changes, but it still takes almost half a year! CITES loves to take people to our plantation to show people how environmental and progressive and this and that it is. But then two weeks later, you ask for a license and suddenly they forgot their visit! Unfortunately, it is still like that. Magaldi, the one who passed away this year, was always a patient man. Now I am there to sort this stuff out, but I can assure you that I have no commercial interest in this anymore. I'm just trying to do the right thing, and Magaldi was always trying to do the right thing. We've been here for so long and still have never had a problem with any environmental regulations.

KB: So I remember this industry very well and I remember when rosewood oil production first started getting into trouble for taking down so many trees. But when the article about distilling leaves and twigs was released, it seemed like a revolution happened overnight. It had such a big influence on the market; do you see it the same way?

IM: Yes, definitely! And I can tell you a lot about it. We originally tried to extract oil from leaves but you need tons and tons of material to make it economically possible. But you know, the rosewood tree has a seed that is identical to another tree, which is some sort of rosewood cousin. It looks exactly the same; the only way you can tell is if you take a leaf, smash it in your hands and give it a sniff. Rosewood will smell and its cousin will not. The guy who first derived rosewood oil from branches and leaves worked for a company that was also building a huge plantation near the rainforest. He asked if I wanted to come with him to see it, and I agreed, but I could tell he thought something was wrong. Well, the plantation had just planted 1,000 trees and they were all the wrong tree!

A lot of people have invested in this product over the years and have not been successful because the key to success starts with making seedlings. Finding seeds is not easy and even when you find them, you can't be sure whether they're rosewood or the cousin tree! So it is very interesting to work with this product but it is also not for amateurs.

KB: That's definitely for sure! Well thank you Ilko, and if I may, one last question. You mentioned that Magaldi produces all organics. Can you just explain why that is the case?

IM: Well they use all natural fertilisers and insecticides; it's just one of the procedures that they have to follow. I was always trying to introduce this concept to others as well because nothing is more natural or organic than the jungle. So I was the one who started with this idea, even with copaiba. Some customers insist that they only buy organic, while others don't really care. Organic has its value and you can tell because a lot of people prefer to buy from Whole Foods, rather than other supermarkets! But it is a cleaner product, no question about that. I'm very passionate about the Amazon; it is my second fatherland and I feel very privileged to live here. I'm part of a family with history in the region and I'm just continuing that tradition. I'm convinced that if you do right, it may take some time, but in the end you will be rewarded.

NOTES:

Prof. Dr. Lauro E.S. Barata gave the Medal Lecture on rosewood at the IFEAT 2018 Cartagena Conference entitled *"Scents from the Amazon"*. IFEAT Members can read or download the paper from the Conference proceedings area of the IFEAT website here: **https://bit.ly/3hJzKZz**

During the IFEAT 1996 Tel Aviv Conference, a paper entitled *"Brazilian Rosewood Oil: The Prospects for Sustainable Production and Oil Quality Management"* was presented. This was by A. Santana, S. Ohashi and L. de Rosa (Faculdade de Ciencias Agrarias do Para, Belem, Brazil) and C. L. Green. IFEAT Members can read or download the paper from the Conference proceedings area of the IFEAT website here: **https://bit.ly/2Xrn9Dr**

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IFEAT SOCIO-ECONOMIC REPORT

LEMON

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

BY DR PETER GREENHALGH

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 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).

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.
α-Thujene	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5	0.2	0.5
α-Pinene	1.5	2.5	1.4	2.5	1.5	3.0	1.5	3.0	1.4	3.0
Sabinene	1.5	2.5	1.3	2.5	1.5	3.0	1.5	3.0	1.4	3.0
β-Pinene	9.0	14.0	10.0	13.0	10.0	16.5	10.0	16.5	7.0	16.0
***p*-Cymene**	0.05	0.35	0.01	0.35	traces	0.40	0.05	0.35	0.05	0.35
Limonene[a]	63.0	70.0	70.0	80.0	60.0	70.0	60.0	68.0	59.0	75.0
γ-Terpinene	8.3	9.5	6.5	8.0	8.0	12.0	8.0	12.0	6.0	12.0
α-Terpineol	0.1	0.25	0.06	0.15	0.09	0.35	0.1	0.3	0.0	0.4
Neral	0.6	0.9	0.3	0.6	0.4	1.0	0.6	1.2	0.2	1.2
Geranial	1.0	2.0	0.5	0.9	0.6	2.0	0.8	2.0	0.5	2.0
β-Bisabolene	0.45	0.9	0.4	0.7	0.45	0.9	0.45	0.9	0.20	0.9
Neryl acetate	0.35	0.6	0.3	0.5	0.3	0.6	0.2	0.5	0.1	0.5
Geranyl acetate	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.

[a] This is regarded as being completely D-limonene by independent chemical and physical analysis.

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 *Primafiori* 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.

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
Production **1,471,429**	*Production* **1,035,711**	*Production* **834,200**	*Production* **794,700**	*Production* **503,500**	*Production* **354,216**	*Production* **890,000**

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

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

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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%
TOTAL	1,668,533	1,419,667	1,448,274	804,319	1,395,858	1,577,637	1,400,000	1,800,000	1,750,000	1,450,000	1,471,429	100.0%

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%
TOTAL	937,000	977,000	834,000	994,000	1,130,000	800,852	1,151,897	1,053,123	1,271,076	1,208,159	1,035,711	100.0%

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%
TOTAL	852,000	771,000	828,000	824,000	904,000	904,000	886,000	790,000	813,000	770,000	834,200	100.0%

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%
TOTAL	426,000	520,000	411,000	546,000	544,000	555,000	490,000	570,000	528,000	445,000	503,500	100.0%

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%
TOTAL	860,000	931,000	624,000	748,000	754,000	662,000	710,000	630,000	1,103,000	925,000	794,700	100.0%

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%
TOTAL	253,084	229,059	244,568	312,314	339,130	308,000	311,000	460,000	490,000	595,000	354,216	100.0%

Source: AILIMPO and World Citrus Organisation

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LEADERS IN ESSENCE

IFEAT SOCIO-ECONOMIC REPORT • LEMON

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 (Huanglongbling – citrus greening disease), citrus black spot (CBS) and citrus canker which affects southern producing countries, notably Argentina, South Africa and Brazil. Mediterranean Basin producing countres (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
Total	**53,744 ha**	**1,675,851 MT**

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.

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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 Cuidad 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 Paolo.

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.

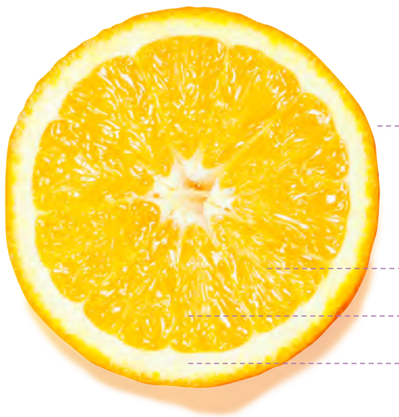
However where the concentration is on the fresh fruit market there are still issues relating to the use of substances that are not globally acceptable. In addition, some approved substances are beginning to lose their effectiveness and other compounds need to be applied. Diligent testing protocols and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



PROCESSING LEMON IN SPAIN

WHAT CAN BE OBTAINED FROM A SPANISH LEMON?

- Cold Pressed Lemon Oil (0.30 - 0.40%)
- Lemon Essence Oil (0.1%)
- Concentration
- Direct Juice (30 - 40%): NFC + Concentrates
- Pulp Cells (1.5 - 2%)
- Wet Peel (50 - 55%) >>> Dried Lemon for Pectin / Animal Feeding

Source: Bredenberg 2011

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.

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
Total	**2,153,400**		**9,735**	**100**

Based on three-year average of estimated lemon processed

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 types of equipment for processing lemons.

1. Italian oil extractors, called pelatrices or sfumatrices, 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.

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
Total	2,101	1,640	1,692	1,318	2,130	1,813	1,766	

Source: Blum and Davalos 2018

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.

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: Federcitrus 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
Packing – permanent labour	22,100
Industry – permanent labour	4,600

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.

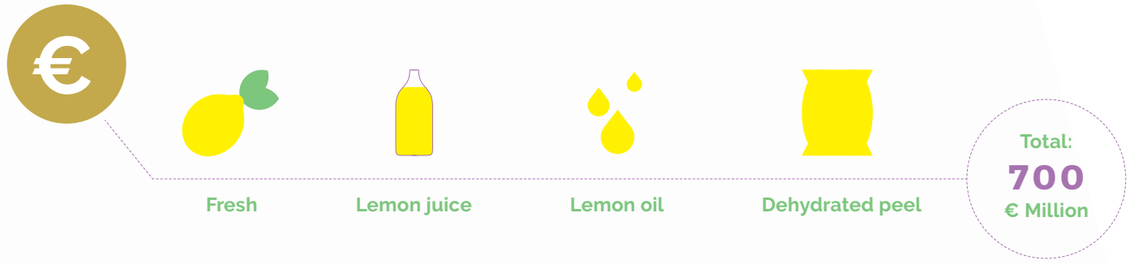
Value of Argentina Citrus Industry 2017 US$ m. (US $1.00 = A Peso 19.00 April 2018)

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

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
Total	90	612,000	516 € million

Source: AILIMPO

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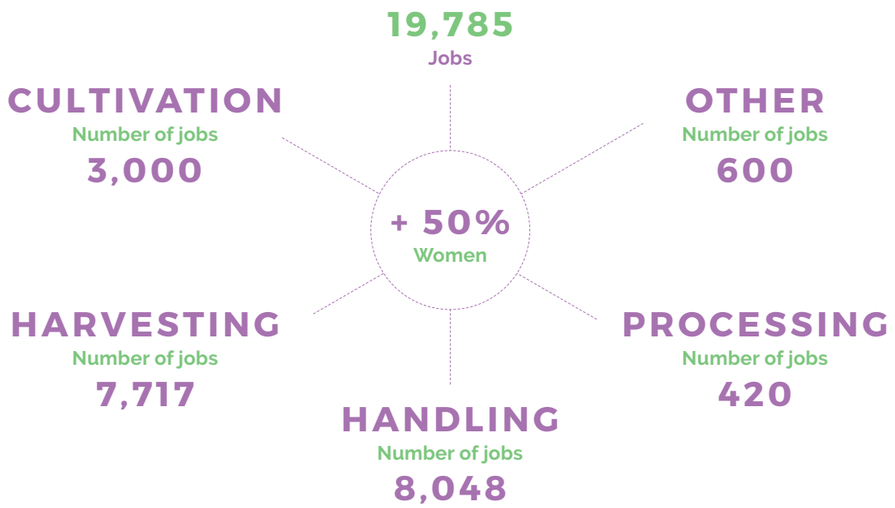
DIRECT EMPLOYMENT GENERATION WAS ESTIMATED AS FOLLOWS:

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

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 directy attributable to lemon oil would be substantially smaller, but nevertheless still substantial.

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

Other environmental policy initiatives include commitments to reduce scarce water usage through more efficient utilisation as well as efforts at CO_2 capture and the achievement of a positive CO_2 balance.

The Spanish lemon sector contributes actively to the fight against climate change by being a real CO_2 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_2.

Measurements of CO_2 emissions were taken along the value chain from growing, transportation, packaging and processing. Lemon groves have a high capacity to capture CO_2 through carbon fixation, and AILIMPO estimated the crop captures the equivalent of 360,550 MT each year. The high CO_2 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_2 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 CO2 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_2 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

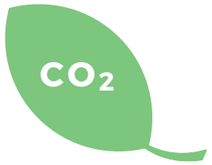
232.4
hm_3/year

COMMITMENT WITH CSR AND SUSTAINABILITY POLICIES

POSITIVE CO_2 BALANCE: NET CO_2 CAPTURE

Positive CO_2 Balance

304,840
MT of CO_2 captured — Equivalent to — 1 year's diesel consumption of 140,000 cars driving 20,000 km/year



Source: AILIMPO

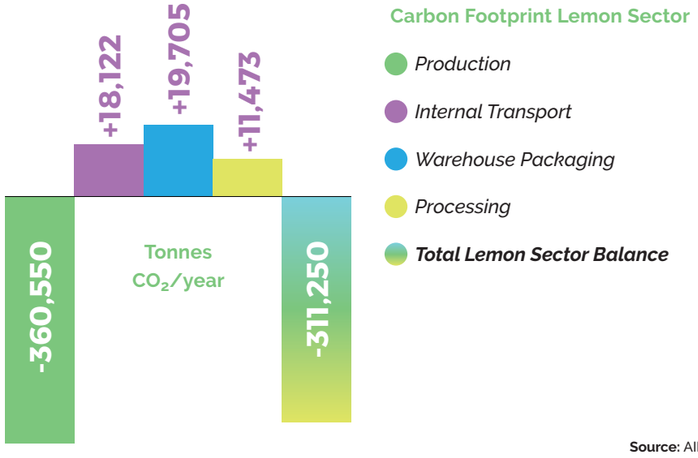
CARBON FOOTPRINT OF THE LEMON SECTOR IN SPAIN

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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MY FAVOURITE

DISTILLED KEY LIME OIL

MY UNFINISHED QUEST FOR NEW SOURCES

BY HUGO BOVILL

IFEAT's regular feature, My Favourite, began with bitter orange in December 2008 and was written by Hugo Bovill, former President of IFEAT from 2005 to 2008. Hugo has written a second My Favourite piece for IFEATWORLD and this one features Key lime oil.

During my 40-year career in essential oils I have tried unsuccessfully to develop additional sources of this complex oil which has historical links to my family. We have been associated with the lime oil industry since the 1930s when my grandfather Jim (EW) Bovill met Mr. Lauchlan Rose, Chairman of Rose Lime Juice. This meeting was of such importance to his company (Treatt-Bovill Ltd, as it was then called) that forty years later the relationship was still appreciated by many of the world's global beverage companies.

Despite lime juice being less stable and containing less vitamin C than lemons, the British government passed a law in 1867 stating that all ships sailing under the Union Jack must carry enough juice for a sailor's daily ration. By stating lime juice, it ensured the "Limeys" (as British sailors were soon nicknamed) were not dependent on Italy for supplies of vitamin C rich juice.

Initially, in 1924, the West Indies and then Ghana (formerly named the Gold Coast) were the United Kingdom's sources of lime oil and juice. The islands of Dominica and St Lucia dominated supply but the increasing frequency of hurricanes during the 1930s significantly reduced the number of plantations as trees were uprooted and plant pathogens blown throughout the islands spreading disease.

Limes were processed by crushing using granite rollers and then the oil was separated from the juice by distillation. Lime oil was a by-product of the manufacture of citrate of lime (a citric acid rich juice). As a result of Italy's dominance and enormous inventories, lime oils became the product and acid juice the by-product of lime processing.

My family's company was appointed to market both West Indian and West

African lime oils on behalf of the Rose Company which was later to become part of Schweppes in the 1950s and then Coca Cola.

One of my earliest memories of the industry is seeing flasks of Cuban lime oil packed in straw lined wooden cases. The unlabelled flasks had to be sampled carefully as there was always one or two of the more valuable dark green cold-pressed oils in a shipment. Disappointingly, during a four-day trip to Cuba in the 1990s, I was unable to visit the one very dilapidated lime factory near Guantanamo Bay.

One of my first tasks during my training in the 1970s was uncorking small aluminium bottle samples from UNPAL (the National Union of Lime Producers of Mexico) and checking the optical rotation which was the main analytical parameter for quality. I can still recollect the volatile fresh top notes.

Mexico had been processing Key limes since the 1930s. By the 1970s more than 500 tonnes a year of oil were exported. Mexico also grows Persian limes which have an inferior flavour. Persian limes are only processed to produce cold pressed oil, not distilled oil. Persian distilled lime oil was produced in Florida during the 1980s by Howard Kendal but did not gain market acceptance as it was perceived as too different from distilled Key lime oil.

Key limes had been grown in Peru for many years for use in ceviche (a fish dish marinated in lime juice). Frequently there could be an extreme oversupply of limes during El Niño years as the quantity of fish caught in the Pacific Ocean could be substantially reduced thereby reducing fresh lime consumption. A Mexican missionary named Porfirio Diaz was based in northern Peru and he introduced the technology for lime processing in 1967. The lime oil price then began its decline from $14.75 to $4.50 per pound in weight, as there was overproduction. In 1982 I made my first visit to Peru which was swiftly followed by a visit to Mexico, hosted by my good friends the Readhimer family who this year are celebrating 50 years of lime processing.

IVORY COAST
with Thierry Duclos (left)

IVORY COAST LIME STILL

In 1987 I visited the Ivory Coast on the west coast of Africa with Thierry Duclos where there was an annual production of lime oil of about 10 tonnes. We had hoped to expand the production, but politics, exchange rates and the lack of a local market for fresh fruit made this uneconomic.

Other attempts in sub-Saharan Africa to cultivate lime have failed. One notable well documented account is in a book called The Africa House by Christina Lamb who visited Shiwa Ngandu in Northern Zambia. Here, Stewart Gore-Browne had a large farm with a lime plantation which he started post the First World War. He was visited by a well-meaning South African who brought him some other citrus trees as a gift. These trees turned out to be diseased and, as a result, the plantation was destroyed in six months. The lime trees were not replanted.

In 2000, I visited Shiwa whilst travelling on the "TAZARA Express", a three-day train journey from Northern Zambia to Dar es Salaam on the coast of Tanzania. The Gore-Browne family, still living on the farm, did not wish to discuss any further essential oil ventures as their grandfather's passion had almost bankrupted the estate. Whilst staying there, we found letters and pamphlets from my grandfather, EW Bovill, who had stayed there on his travels.

I also visited Burundi where a well-connected politician had propagated lime trees from seeds given to him by a Haitian diplomat at a UN conference. Having seen the trees, I was optimistic of success as land and labour was freely available but after two years the trees suddenly died from what is known as Gore-Browne disease as happened at Shiwa. However, the small lime still is now used for patchouli oil production.

There are still one or two places that I have yet to explore to evaluate the potential of processing their Key limes as a viable additional source of lime oil production, but they will not be as interesting as sub-Saharan Africa.

BRITISH EMPIRE MARKETING BOARD POSTER
photographed at the Victoria Falls Hotel, Zimbabwe

ACKNOWLEDGEMENTS

History of L. Rose and Company 1965 by Lachlan Rose

Distilled Lime Oil, an undated pamphlet by AC Stirling

Thierry Duclos 1987 for the photographs of the Ivory Coast visit

Readhimer family for information on Mexican and Peruvian lime processing history

IN THE NEWS

CHEMICAL IN ESSENTIAL OILS MAY TREAT PARKINSON'S DISEASE

According to MedicalNewsToday, a chemical in essential oils may treat Parkinson's disease.

A discovery by researchers of a compound that prevents the death of dopamine neurons in a mouse model of Parkinson's disease could herald a step change in treatment.

The compound, called farnesol, occurs naturally in plants and is a component of several essential oils, including citronella, lemongrass, and balsam. It has long featured as an ingredient in the manufacture of perfumes. The compound is also widespread in animal tissues.

Read the full article at: https://bit.ly/2TTaHdH

ESSENTIAL OILS HELP TO STOP INVASIVE BEETLES FROM EATING PALM TREES

The red palm weevil, a beetle known for its devastating effect on palm trees, can be stopped in its tracks by clove and thyme oil – offering hope of new control options for growers hit hard by the insect's damage to their crops.

Researchers at the University of Malaysia, Terengganu tested the effect of eight chemicals derived from the two essential oils on feeding by larvae of the red palm weevil (*Rhynchophorus ferrugineus*).

Anyone with a subscription to the New Scientist can read the full article at: https://bit.ly/3lJJrdp

RED PALM WEEVIL

NEW IFEAT MEMBERS

Below is a list of new IFEAT members who had joined by 16th September 2021

Aromáticas del Zalabí S.L.

C/Martin Perez de Ayala 1, 18008 Granada, Spain
Contact: Ms Patricia Salsas
Email: patricia@aromaticaszalabi.com
Web: www.aromaticaszalabi.com

Family-owned business that combines a deep-rooted agricultural tradition with vast experience serving the F&F industry, restoring the farming and distillation of native aromatic plants.

Nikhil Naturals Pvt. Ltd

54/34, Naya Ganj, Kanpur - 208001, India
Contact: Mr Nikhil Gupta & Deepak Tiwari
Email: rxsandalnik@gmail.com & logistics@nikhilaromas.com
Web: www.nikhilaromas.com

NNPL is a corporate, family-owned company focusing on customer satisfaction through good quality and competitive prices of essential oils.

Blue and Purple (Hangzhou) Import and Export Co., Ltd

Room 803, Xingchauang centre, 76 Xingqiao North Road, Xingqiao street, Yuhang District, Hangzhou City, Zhejiang Province, China
Contact: Honghai Deng & Peral
Email: peralng1116@gmail.com

We are a trade company located in Hangzhou, China. Our business is importing a variety of oils from all over the world and selling them in the Chinese market. Our products include essential oils, vegetable oils and hydrosols.

PT. Sagira Aroma Indonesia

Millenium Industrial Estate, Jl. Millenium 16 Blok K1 No.5, Panongan, Cikupa, Tangerang Banten 15711, Indonesia
Contact: Thomas Artanto & Dr Yosefa Harijadi
Email: thomas@sagiraaroma.com & yosefa@sagiraaroma.com
Web: www.sagiraaroma.com

Essential oil and aroma chemical manufacturer with Indonesian origin - precious quality from the heart of nature.

Sluys International

Nijverheidsstraat 1, 2570 Duffel, Belgium
Contact: KwangErn Liew
Email: kwangwern@sluys.com
Web: www.sluys.eu

Sluys International is a Belgium-based manufacturer of flavour, drink concentrate and beverage emulsion. Sluys is a purveyor of taste and smell within the varied sub-sectors of food and beverage.

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