
ADDRESSING UNITED NATIONS SUSTAINABLE DEVELOPMENT GOAL (SDG) 13, TO TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS EFFECTS



CARBON FOOTPRINT OF THE LEMON SECTOR IN SPAIN

0. INTRODUCTION

According to MAPA data, 45,832 hectares of lemons were cultivated in 2019. Of these, 7,117 are organically farmed (3,729 ha certified to be marketed as organic and the rest is being converted).

As far as lemon production is concerned, according to AILIMPO data for the 2019/20 season, 1,208,159 tonnes were produced.

Once harvested, the fruit can be marketed for fresh consumption or for processing.

In the 2019/2020 season, a total of 252,167 tonnes of lemons were sent to processing, while 910,468 tonnes went to the fresh market. The main destination for fresh produce was EU countries, followed by the domestic market and non-EU countries (table 1).

Table 1. Quantities of lemons traded by destination. 2019/20

Destination	Tonnes
EUROPEAN UNION COUNTRIES	693,426
NON-EU COUNTRIES	32,542
DOMESTIC MARKET	184,500
TOTAL FRESH	910,468
PROCESSING	252,167
LOSSES	45,524
TOTAL	1,208,159

Source: AILIMPO

1. PURPOSE AND REASON FOR THE REPORT

In recent times, a new concept has emerged in supplier-customer-consumer relations in the agri-food sector: **the need and requirement to be SUSTAINABLE**. This is a new work and relationship approach throughout the supply chain.

In 2015, the UN adopted the 2030 Agenda for Sustainable Development. This is an opportunity for countries and their societies to embark on a new path to improve the lives of all, while leaving no one behind. The Agenda has 17 Sustainable Development Goals (SDGs), ranging from eliminating poverty **to combating climate change**, education, women's equality, environmental protection and the design of our cities.

Therefore, sustainability is a challenge for **economic and agri-food development**.

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AILIMPO has been playing a key role for years in preparing the sector to adapt to the challenges of sustainability. The pivotal strategy of this vision for the future of the Spanish lemon sector is its sustainable operating model based on three key pillars: financial, environmental and social.

Sustainability, as a driver of innovation and the future, is therefore part of the new vision of the sector promoted by AILIMPO and requires the commitment and collaboration of all the players in the value chain integrated in the interbranch association: producers, cooperatives, exporters and processing plants.

The National Greenhouse Gas Inventory shows that the agricultural sector in Spain is responsible for 11.9% of total emissions. For this reason, our companies must develop strategies to reduce emissions by promoting renewable energies to the detriment of fossil fuels, investing in R&D+I and working across the board with the international community to achieve global commitments on climate change.

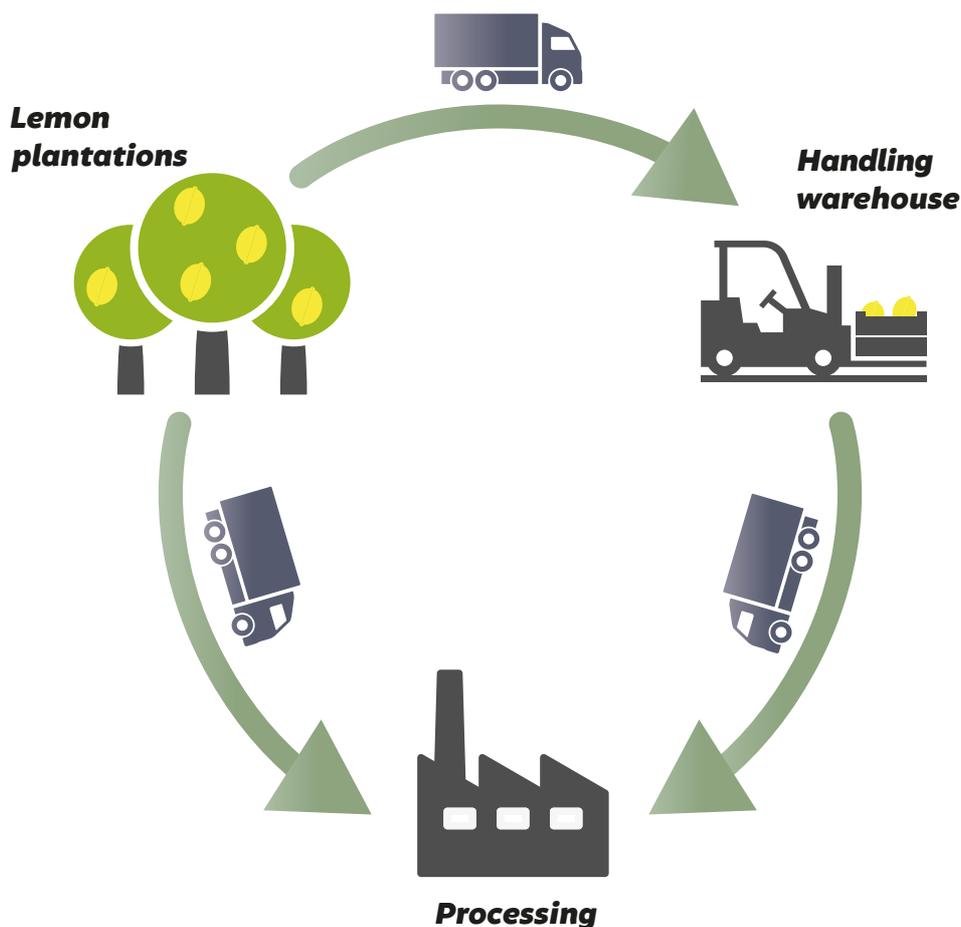
According to the Sectoral Guide on SDGs in the Agri-Food Sector published by the Global Compact Spanish Network (UN GLOBAL COMPACT), in relation to the Climate Action Target, **the challenge identified in our country is to promote the calculation and reduction of the environmental footprint, with the main indicator being the quantification of the greenhouse gases generated by the sector (CARBON FOOTPRINT).**

Therefore, in this report on the Carbon Footprint of the Lemon Sector, we address UN Sustainable Development Goal (SDG) 13, which aims to take urgent action to combat climate change and its effects.



2. METHODOLOGY USED

Lemons are produced on farms and then transported to handling warehouses (where the fruit is packed and sent to the markets for fresh consumption) or to industry (where they are processed into juice, essential oils and dehydrated lemon peel). In the handling process, part of the fruit is discarded, being redirected from the packaging warehouses to processing.



From the farm until it leaves the handling warehouse or processing plant for customers, there are a number of CO₂ fixations and emissions. The aim of this report is to quantify them in order to produce the sector's Carbon Footprint.

For this purpose, the methodology described below has been used.

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CO₂ fixation on farms

This section has analysed the carbon fixation transferred to CO₂. The data obtained in the IVIA study (Iglesias, J.C et al. 2012) were used for this purpose by adapting them to lemon cultivation.

We have considered the difference between organic and conventional cultivation as the net CO₂ fixations are higher in the former as a result of lower nitrogen fertiliser inputs. An input of 240 kg of N/ha per year has been considered in conventional cultivation (figure established in the Region of Murcia Code of Good Agricultural Practices) while in Organic Agriculture we have taken into account the maximum authorised value of nitrogen (170 kg of N/ha per year). By transferring the data on nitrogen inputs to the Ministry of Ecological Transition's Carbon Footprint Calculator, organic cultivation achieves a CO₂ fixation that exceeds those that are conventionally farmed by 0.43 t/ha per year as a result of lower nitrous oxide emissions.

We have taken into account a planting pattern of 7x5 metres (i.e. 300 trees per hectare) to calculate the fixation data per tree.

According to Carvajal, M et. al., the lemon tree is the crop that achieves higher carbon fixation values than other citrus and tree species. For this reason, within the range established by the IVIA (6.15- 8.77 t CO₂/ha per year), we have considered a fixation of 7.8 t CO₂/ha per year for conventional farming and 8.23 t CO₂/ha per year for organic farming.

Emissions during transport

In relation to transporting the fruit from the farms to the handling warehouses or processing plants (or the fruit that arrives at the warehouses and is finally sent for processing), the footprint has been calculated assessing an average distance of 50 kilometres and taking into account the emission value of 300 gr of CO₂ /tonne per km (for a medium-sized truck, the Intergovernmental Panel on Climate Change (IPCC) estimates emissions in the range of 170-520 grams of CO₂/ tonne per km).

Emissions of CO₂ in handling warehouses and processing plants

In order to obtain data on emissions generated in the handling warehouses and in the processing plants, a survey was carried out and sent to all members within the interbranch association.

With the information collected, we calculated the carbon footprint of the survey data set (using the Ministry for Ecological Transition's carbon footprint calculation tool). As the sample is representative, we extrapolated the emissions data from the warehouses and processing plants surveyed to the sector as a whole, calculating the carbon footprint at each stage.

Finally, with the data from each process, the overall balance of the Sector's Carbon Footprint is drawn up.

3. ANALYSIS OF THE CARBON FOOTPRINT OF THE LEMON SECTOR. EMISSION REDUCTION MEASURES

3.1 Fixed CO₂ at farm level

As indicated in paragraph 2 of this report, for the analysis of the CO₂ fixation of lemon plantations, the data from the IVIA study have been taken into account. This study takes into account all emissions related to cultivation. The net fixation of citrus crops is between 6.15 and 8.77 t CO₂/hectare per year.

The following table shows all the information analysed and the calculation of the net CO₂ fixation of lemon plantations, taking into account lemon production data (source AILIMPO and MAPA) and national surface area data (MAPA), differentiating between organic and conventional cultivation.

Table 2. CO₂ fixation in lemon plantations

	CONVENTIONAL LEMON	LEMON ECOLOGICAL	LEMON TOTAL
Production 2019/20 (tonnes)	1,070,894	137,265	1,208,159
Area (hectares)	38,715	7,117	45,832
IVIA balance (t CO ₂ /ha)	- 7.8	-8.23	
t CO ₂ / t of product	-0.28	-0.43	
Emissions total balance (t CO ₂ / year)	-301,977	-58,573	-360,550

Source. Prepared inhouse. AILIMPO, MAPA and IVIA data

Therefore, the total CO₂ fixation in lemon plantations amounts to 360,550 tonnes per year.

As shown in Table 3, on average, 7.87 tonnes of CO₂/ha per year is fixed, which results in a figure of 26,223 grams of CO₂/tree.

For every kilo of lemon produced, the net fixation of the crop is 298 grams of CO₂ per year.

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Table 3. CO₂ fixation in lemon plantations. Most significant data

CO ₂ fixation in the field (t CO ₂)	-360,550
Lemon area (ha)	45,832
Lemon production (tonnes)	1,208,159
t fixed CO ₂ /ha	- 7.87
Grams fixed CO ₂ /tree	-26,223
t of fixed CO ₂ /t lemon	- 0.30
Grams of fixed CO ₂ /Kg lemon	-298

Source. Prepared inhouse

The high figures of CO₂ fixation indicated are due to the practices that producers are carrying out, which include the following:

- The area under organic cultivation has tripled in recent years in Spain. Between 2012 and 2019, the number of hectares increased from 1,708 to 7,117 hectares (MAPA, 2019). Organic farming contributes to reducing emissions as the net fixation on organic farms is higher than on conventionally farmed farms.
- The shredding and incorporation of pruning residues reduces the evaporation of water from the soil and increases the organic matter in the soil, thereby increasing the CO₂ stored in the soil.
- Since 92% of the lemon area has localised irrigation systems with no soil tillage, no fossil fuels are consumed in land development. In addition, non-tillage leads to less mineralisation activity of organic matter, which favours the fixation of more carbon in the soil.
- The optimisation of irrigation and the use of techniques such as moisture probes, mulch nets to reduce evaporation or the Controlled Deficit Irrigation technique lead to reduced water consumption and therefore a reduced need for electricity for irrigation, thus reducing emissions.
- Significant investment has been made in modernising agricultural machinery in recent years. Today's farms are equipped with more modern and efficient tractors that are able to reduce fuel consumption and CO₂ emissions.

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3.2 CO₂ emissions while transporting the product to packaging warehouses and processing plants

There are CO₂ emissions when transporting the product to the handling centres or processing plants.

As indicated in section 2, an average distance of 50 kilometres has been estimated and the emission figure of 300 g of CO₂/km per tonne has been considered. The calculation of total emissions during transport is shown in table 4.

Table 4. Emissions during transport

	2019/20 PRODUCTION (tonnes)	Emissions (grams of CO ₂ /Km per tonne)	t CO ₂ /t lemon	TOTAL TRANSPORT EMISSIONS (t CO ₂ /year)
LEMON	1,208,159	300	0.015	18,122

Source. Prepared inhouse

As we can see in table 5, the total emissions from transporting lemons from the field to the warehouse or processing plant is 18,122 tonnes of CO₂ per year. If this is considered per hectare of crop, the figure is 0.395 t CO₂/ha (1,318 grams of CO₂ /tree). For every kilo of product obtained in the field, transport involves emissions of 15 grams of CO₂.

Table 5. Emissions of CO₂ during transport. Most significant data

Emissions of CO ₂ during transport (t CO ₂)	18,122
Lemon area (ha)	45,832
Lemon production (tonnes)	1,208,159
t CO ₂ /ha	0.395
gr CO ₂ /tree	1,318
t of CO ₂ /t lemon	0.015
Grams of CO ₂ /Kg lemon	15

Source. Prepared inhouse

The freight transport sector is renewing its fleet. For more efficient vehicles with lower fuel consumption per kilometre driven. This means a reduction in emissions.

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3.3 Emissions in handling warehouses

Emissions during the handling process are due to the energy consumption of the machinery used and cooling the product.

The total emissions during this process are 20.61 grams of CO₂/Kg of packaged fruit, which represents a quantity of 19,705 tonnes of CO₂ per year for the lemon producing sector as a whole.

The impact of handling on the total lemon area amounts to emissions of 0.43 t of CO₂/ha per year (1,433 grams of CO₂/tree).

Table 6. Carbon footprint of production destined for the fresh market (packaged in warehouse)

	gr CO ₂ /kilo of product
Field production	-298.43
Transport (to the packing warehouse)	15.00
Warehouse packaging process	20.61
TOTAL BALANCE	-262.82

Source. Prepared inhouse

As shown in table 6, for every kilo of product that is manufactured, the carbon footprint is a net fixation of 262.82 grams of CO₂.

In recent years, significant advances have been made in the handling warehouses in renovating machinery and cold stores. The use of pallet trucks and electric forklift trucks has also become widespread. As a result, there has been a significant reduction in the carbon footprint of these facilities. In addition, some companies in the sector have photovoltaic production facilities, which reduces electricity consumption by using their own 100% renewable energy.

3.4 Emissions of CO₂ in the lemon processing plants

The industry processes lemons, producing mainly juice, essential oils and dehydrated lemon peel.

Emissions in the processing plants are derived from the machinery used, with energy consumption being very high, especially in the evaporation process to obtain the concentrated juice.

The processing plant's annual carbon footprint amounts to 11,473 tonnes of CO₂, which, when translated into production, results in emissions of 45.5 grams of CO₂/Kg of processed lemon.

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In total emissions per area, processing has an impact of 0.25 tonnes of CO₂/hectare of crop per year (834 grams of CO₂/tree).

CO₂ fixation per kilo of product processed (table 7) is 237.93 g of CO₂ /Kilo.

Table 7. Carbon footprint in production for processing

	gr CO ₂ /kilo of lemon
Field production	-298.43
Transport (to processing plant)	15.00
Transformation process	45.50
TOTAL BALANCE	-237.93

Source. Prepared inhouse

With regard to improvements made in recent years to reduce emissions, processing plants have opted to produce renewable energies (photovoltaic) with the aim of reducing dependence on fossil fuels. Modernising facilities and machinery and using electric forklifts and pallet trucks to transfer goods clearly reduce their carbon footprint.

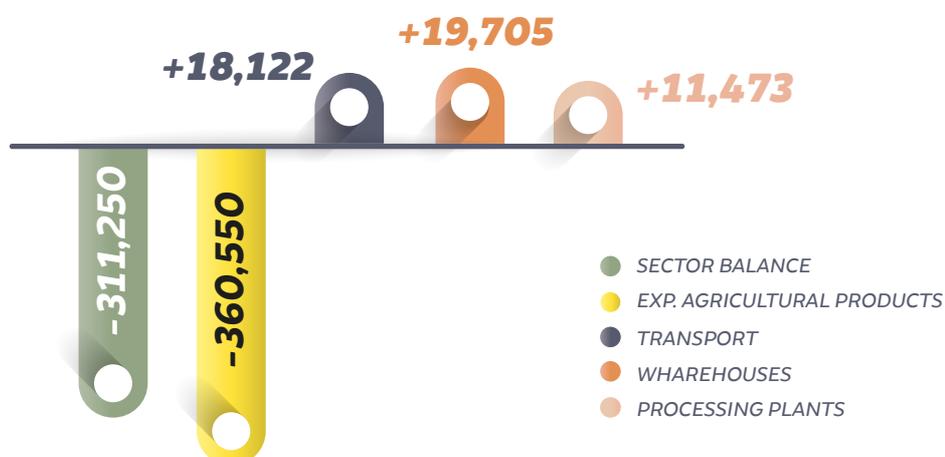
3.5 Lemon sector carbon footprint balance

As shown in the previous sections, the overall balance is fully influenced by the carbon fixation that takes place on farms.

As shown in chart 1, the lemon sector is prominently a CO₂ fixer. The total balance reflects an uptake for the sector as a whole of 311,250 tonnes CO₂/ year. Trees on farms are capable of capturing 360,550 tonnes/year (net of crop emissions), while transport, handling in warehouses and processing emit a total of 49,300 tonnes of CO₂ per year. The industry processes lemons, producing mainly juice, essential oils and dehydrated lemon peel.

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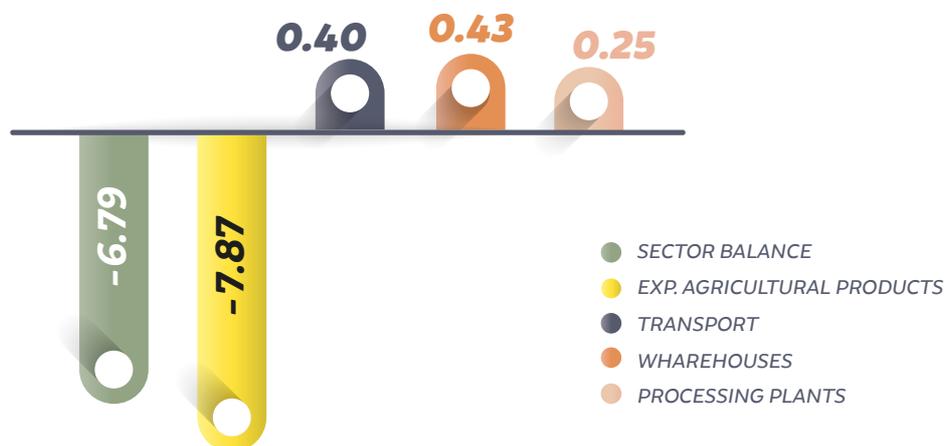
Chart 1. Carbon footprint of the lemon sector (tonnes of CO₂)



Source. Prepared inhouse

The data per unit area show that the average balance on farms is negative at 7.87 tonnes of CO₂/hectare, while the impact of emissions in the other phases on the surface area is 0.40 t CO₂/ha in transport; 0.43 t CO₂/ha in the handling warehouses and 0.25 t CO₂/ha in processing plants. In total, for the sector as a whole, the average net CO₂ fixation is 6.79 tonnes/ha. (chart 2).

Chart 2. Carbon footprint balance per unit area (tonnes of CO₂/hectare)



Source. Prepared inhouse

Net carbon fixation per tree is 22,637 grams of CO₂.

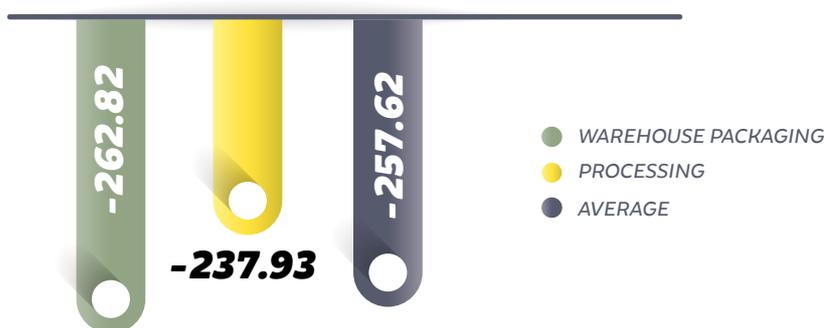
As for the balance of the carbon footprint per kilo depending on its destination (packaging warehouse or processing plant), the following chart shows that, in the case of fruit destined for processing, the net fixation is 237.93 grams of CO₂/kilo of lemon, while in the case of fruit intended to be sold fresh the figure is 262.82

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grams of CO₂/kilo of lemon. Since the quantity of lemons destined for storage is much higher than the quantity processed, the average net fixation is 257.62 grams of CO₂/kilo of fruit.

The lower net fixation of fruit destined for processing is a consequence of the higher energy consumption in processing lemons.

Chart 3. Quantity of fixed CO₂ according to the production destination
(grams CO₂/kilo of lemon)



Source. Prepared inhouse

4. RECOMMENDATIONS FOR INCREASING NET CO₂ FIXATION

Although the sector is clearly an atmospheric CO₂ fixer and its carbon footprint is extremely favourable, there are aspects that would encourage greater fixation in the future. Therefore, in the following table, we indicate a number of recommendations in each of the areas analysed in this report that would lead to an improvement in its carbon footprint.

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Farms	Transport	Handling warehouses and Processing plants
Continuing to innovate in irrigation efficiency and optimisation of water and fertiliser use (especially nitrogen fertilisers).	Continuing the renewal of vehicle fleets for others with lower emissions and even using alternative energies to fossil fuels.	Conducting energy audits and carbon footprint analysis.
Increasing soil organic matter through the use of soil amendments or by planting green cover crops and incorporating them into the soil.	Training goods drivers in efficient driving.	Selection of electricity suppliers with Guarantee of Origin that offer a high percentage of renewable sources (even 100%).
Promotion of organic farming. The limitation of nitrogen fertilisation to organic amendments, the limited use of phytosanitary treatments and the maintenance of a better soil structure have an impact on a higher CO ₂ fixation in the soil and the generation of lower emissions.		Investments in renewable energy.
Promotion of biological and biotechnological control to reduce the number of phytosanitary treatments.		Where appropriate, replace cooling systems with those using gases that do not affect global warming.
Selection of electricity suppliers with Guarantee of Origin that offer a high percentage of renewable sources (even 100%).		Renewal of vehicle fleets for less polluting vehicles (hybrid or electric).
On-farm renewable energy generation to cover the electricity needs of irrigation facilities.		Continue to renew equipment with more efficient machinery.
Continue modernising agricultural machinery.		Energy recovery from organic waste.

5. CONCLUSIONS

The calculation of the environmental footprint of our activity, and in this case of the Carbon Footprint, is part of the sustainability policy of the AILIMPO interbranch association in the environmental area as well as contributing to UN Sustainable Development Goal (SDG) number 13, on urgent measures to combat climate change and its effects.

Spain's lemon plantations have a large capacity to capture atmospheric CO₂. As a result, the net fixation of the crop amounts to 360,550 tonnes of CO₂ per year.

Although the sector emits CO₂ in the course of its business at an amount of 49,300 tonnes of CO₂ (18,122 during transport, 19,705 in handling and packaging warehouses and 11,473 in processing plants), **we conclude that its net carbon footprint is 311,250 tonnes of CO₂ per year.**

Therefore, **the lemon sector in our country actively contributes to the fight against climate change by being a real carbon sink.**

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