Global Juice Sustainability Report

2024

Sharing Knowledge Globally
International Fruit and Vegetable Juice Association
IFU
SCIENCE • STANDARDS • MARKETS • SUSTAINABILITY

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Foreword from the President

Kees Cools, IFU President

This year the IFU is celebrating its 75th anniversary. During all years of its existence the IFU membership has worked hard, on developing a global infrastructure and supply chain, that delivers liquid fruit and vegetables with an authentic healthy profile to fit many consumer food and beverage products.

To do this, sharing knowledge on regulatory, technology, analysis, science and nutrition are vital elements of support. During all these years the juice industry has matured and attracted many new companies and consumers worldwide. Huge investments went into increasing plantations, processing plants, logistics and bottling and packing facilities. Efficiency improvement on crops, yields, productivity, use of resources and processing methods became a constant factor to support higher quantitative and qualitative results.

Challenges from low crops caused by bad weather, geo political issues creating logistic and tariff problems have always been there, however the current recent disruptions in the supply of various fruits and vegetables have put our industry in crisis mode. Significant adaptation efforts in some of our agrifood systems are crucial to avoid future raw material supply and nutrition being at risk.

Several years ago IFU designed its Sustainability Roadmap. The headline: from profitability for sustainability to sustainability for profitability, today is proving to be a real reality with the challenges in orange juice as a major example.

The IFU vision on sustainability in our industry requires a development throughout the whole juice supply chain, bringing all stakeholders to the same collective objectives. The third IFU sustainability report shows, that in our industry a large variety of measures and initiatives on all continents are taking place. There is water resources initiatives in northern Africa and Argentina, Young people & farmers empowerment in Nigeria and Ecuador, best practices and decarbonization projects in Peru, the USA and Vietnam. A more holistic approach on sustainability we see in Germany and Poland.

All of these examples and many more, are proof of our sector's commitment to support securing, the present and future processed fruit & vegetable requirements without compromising future generations of juice consumers.

IFU SWG Chair's Foreword

David Berryman, SWG Chair

The IFU Sustainability Working Group (SWG) is now in its third year. A lot of water has flowed under the bridge since we started. So, and please excuse the pun on that old English saying, Water Management has been a focus for the group this year, the practical examples of which can be seen in the several articles in this year's report.

The warming of the atmosphere has changed the global climate dramatically and, in the short term at least, irreversibly. A warmer atmosphere means more water in the air, which we can see in often dramatic changing precipitation patterns. It means that regions which previously saw moderate levels of rainfall are now seeing floods. Areas which previously saw very little precipitation are now enduring severe droughts. And vice versa. Such rapid changes from season to season can have untold and often unforeseen consequences for societies around the world. The fruit juice industry is technologically mature, and is capable weathering many storms, but, if there is no fruit on the tree, then there is simply no juice in the bottle.

This past year we have seen the effects of climate change in our industry. Whilst Europe was suffering from inundations not seen before, droughts in Brazil during the blossom time led to poor orange harvests, leaving juice producers struggling to fulfil contracts, let alone keep prices down. When we see this scenario with repeating regularity, we realise we are witnessing a genuine climate crisis here and now. But we can and, indeed, must work towards at least ameliorating our position. And every little helps. If we can reduce our carbon footprint, it will help slow the advance of climate warming. If we can manage the utilisation of our water, it will help. And there are some very exciting, ingenious and clever ways of reducing the water needed to run our factories. I really like the idea of using condensate in from the juice concentration process – it's using water from the fruit itself!

At a time when we seem to be living on a conveyer belt of troubling news, I want to share a little piece of optimism I have about our industry. You may be aware that up to a third of food in Europe and North America is wasted, goes to landfill and is becoming a huge concern. The waste food is, of course, devoured by organisms living happily under the rubbish, but, because they digest in the absence of oxygen, they emit methane, which can be as much as eighty times more potent as a greenhouse gas than carbon dioxide. But the good and encouraging news for our industry is that, as far as my somewhat limited research has revealed, almost no juice ends up in landfill. The long shelf life developed in our sophisticated industry is a very important and neat way of ameliorating the greenhouse effect. Moreover, the circular economy can be implemented to upgrade the produced by-products. In our industry nothing is wasted. Therefore, the juice production can be seen as a bright light shining in the dark!

Having spent three years in the position of Chair of the SWG, it is time for me to step aside. I would like to thank Aintzane for her unflagging hard work and all of you for your support in this collaborative team effort. Shannon Doherty, Sustainability Manager of the Australian Beverages Council, has agreed to take over as chair and I am so happy to leave it in her very capable hands.

My best wishes to you all, David Berryman

An Overview of Sustainability Initiatives in the Fruit Juice Sector

Aintzane Esturo, IFU Technical Director

The fruit and vegetable juice industry faces increasing pressure to adopt sustainable practices. These efforts not only ensure the preservation of natural resources but also support the economic and social well-being of communities involved in the production chain. The IFU Sustainability Working Group has been gathering information on various sustainability initiatives that are of interest for the sector.

This document provides, as first approach, the names and links of key sustainability initiatives applicable to the fruit juice sector. Each initiative emphasizes a different aspect of sustainability, from environmental conservation and water management to social equity and transparency. These are the initiatives identified:

Initiative	Website
Sustainable Juice	http://sustainablejuice.com/
Sustainable Juice Covenant	https://www.idhsustainabletrade.com/
Sustainable Juice Platform	https://sustainablejuiceplatform.eu/
JuicyChain	https://juicychain.org/
Open Food Chain	https://openfoodchain.com/
European PET Bottle Platform	https://www.epbp.org
IFU	www.ifu-fruitjuice.com
Fujitsu/BWT	
Rainforest alliance	www.rainforest-alliance.org
Fairtrade	https://www.fairtrade.net/product/fruit-and-juices
Glass Alliance Europe	https://glassallianceeurope.eu/position-category/environment/
GRASP Global GAP	www.globalgap.org
Sustainable Agriculture Initiative (SAI)	https://saiplatform.org/
SEDEX	www.sedex.com
Social Accountability International - SAI	https://sa-intl.org/
BSCI (Business Social Compliance Initiative)	www.amfori.org/content/what-bsci
Worldwide Responsible Accredited Production WRAP	https://wrapcompliance.org/en/about/what-we-do/#
WRAP charity, working with governments, businesses and citizens around the globe	www.wrap.org.uk
United Nations Sustainability Development Goals	https://sdgs.un.org/goals

Initiative	Website
Science Based Targets initiative (SBTi)	https://sciencebasedtargets.org/
Oxfam	www.oxfam.org/en
ITC	www.itcportal.com/sustainability/index.aspx
International Labor Organization ILO	www.ilo.org
The Consumer Goods Forum	www.theconsumergoodsforum.com/social-sustainability/sustainable-supply-chain-initiative/key-projects/benchmarking-recognition/global-social-compliance-programme/
EcoVadis	https://ecovadis.com
B-Corp	www.bcorporation.net/en-us/certification/
Fair for life & For life	https://fairforlife.org
Global Reporting Initiative (GRI)	www.globalreporting.org
CDP (previous Carbon Disclosure Project)	www.cdp.net/en
Aim-progress	https://aim-progress.com/
IFOAM organics international	www.ifoam.bio
Sustainable Iniciative of South Africa SIZA	https://siza.co.za/
The Organisation for Economic Co-operation and Development (OECD)	https://www.oecd.org/
ISO 26000:2010 Social Responsibility	www.iso.org/iso-26000-social-responsibility.html
Sustainable Finance Lab (SFL)	www.sustainablefinancelab.se
Zerya Zero pesticide residues	www.zerya.org/en/
World Farmers Organisation	https://www.wfo-oma.org/.
International Union of Food	https://www.iuf.org/
Net-Zero Climate Strategies and Emission Reduction Solutions	https://carbonsink.it/en/
High Alttitude CO2 capture	https://www.highopeslabs.com/
BIER Beverage Industry Environmental Roundtable	https://www.bieroundtable.com/news/the-beverage-industry-environmental-roundtable-bier-releases-latest-greenhouse-gas-ghg-emissions-sector-guidance/
SBTI Science-Based Targets Initiative	https://sciencebasedtargets.org/sectors/forest-land-and-agriculture
IFS	https://www.ifs-certification.com/en/esg-check-module

Some initiatives are geographically local, others are global; some are exclusive for the juice sector others are general for food or all type of products; some are certifiers other just contribute to improve the impacts; some are focused on environmental issues while others focus on social aspects.

Many industries of the fruit juice sector actively respond to global sustainability challenges through initiatives that address environmental, social, and economic dimensions. By leveraging technologies to improve transparency and implementing water and energy-saving practices, the sector is taking important steps to reduce its ecological footprint while ensuring a fair and equitable supply chain. Continued collaboration among producers, stakeholders, and governing bodies is essential to achieving long-term sustainability goals in the industry.

The Time to Act is Now: Water Resources in Africa and the Maghreb: A Call to Action for the Beverage Industry

Slim Othmani
IFU Africa Ambassador

Water is one of the most fundamental resources for life, underpinning health, food security, economic development, and environmental sustainability. However, the increasing scarcity of water due to climate change, population growth, and unsustainable practices is posing a serious threat, particularly in arid and semi-arid regions like Africa and the Maghreb.

In the Maghreb, the effects of water stress are becoming more severe. Countries like Algeria, Morocco, and Tunisia have made significant investments in water infrastructure over the past few decades—desalination plant, building dams, canals, and irrigation systems to address the challenges posed by limited rainfall and growing demand. Yet, these efforts are no longer sufficient. Water resources are dwindling, and the current usage patterns are unsustainable. Population growth, agricultural expansion, industrialization, and tourism are exacerbating the pressure on already limited water supplies. Rainfall is unevenly distributed, and droughts are becoming more frequent due to the impacts of climate change. This situation calls for urgent action and a complete rethinking of water management strategies.

As key actors in the water value chain, the beverage industry plays a crucial role in this effort. Water is the primary ingredient in their beverage products, and it is used extensively throughout production processes. The industry must recognize its responsibility to ensure the sustainable management of water resources and adopt best practices in water conservation. The time to act is now.

The Water Crisis in Numbers

Globally, freshwater use has increased sixfold over the past century, and it continues to rise by about 1% per year. Agriculture accounts for roughly 69% of global water withdrawals, while industries, including beverage production, and municipal uses make up the rest. Although only 0.3% of the world's water resources are usable by humans, there is still enough water to meet global needs if it is managed efficiently. Unfortunately, more than 2 billion people live in countries experiencing high water stress, and 1.6 billion face 'economic water scarcity,' where infrastructure is inadequate to access available water.

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In the Maghreb, the growing gap between supply and demand for water is alarming. The three countries—Algeria, Morocco, and Tunisia—share several critical water sources, including the aquifer system of the northern Sahara and transboundary rivers such as the Oued Majerda. Political tensions over these shared resources highlight the urgency of cooperation and integrated management strategies.

In the Maghreb, the effects of water stress are becoming more severe.

A New Approach: Sustainability and Cooperation

It is clear that the Maghreb's water crisis cannot be solved by relying on past policies and outdated management practices. A new, holistic approach is needed—one that balances economic, social, and environmental sustainability. Policymakers must prioritize water conservation, efficient use, and equitable distribution. This will require improved infrastructure, smarter agricultural practices, and stronger cooperation between nations.

Moreover, businesses, especially those in water-intensive industries like beverages, must step up. They have a unique opportunity to lead by example, adopting practices that minimize water use and investing in technologies that promote sustainability. Corporate water stewardship is not only a moral imperative but also a strategic business decision, as the continued availability of water is essential for long-term success.

The Role of the Beverage Industry

The beverage industry must acknowledge the significant role it plays in water consumption and commit to sustainable water management across its value chain.

This includes:

- Reducing water use in production processes.
- Recycling and reusing water wherever possible.
- Engaging in community initiatives that improve access to clean water.
- Supporting policies that promote sustainable water use and infrastructure development.

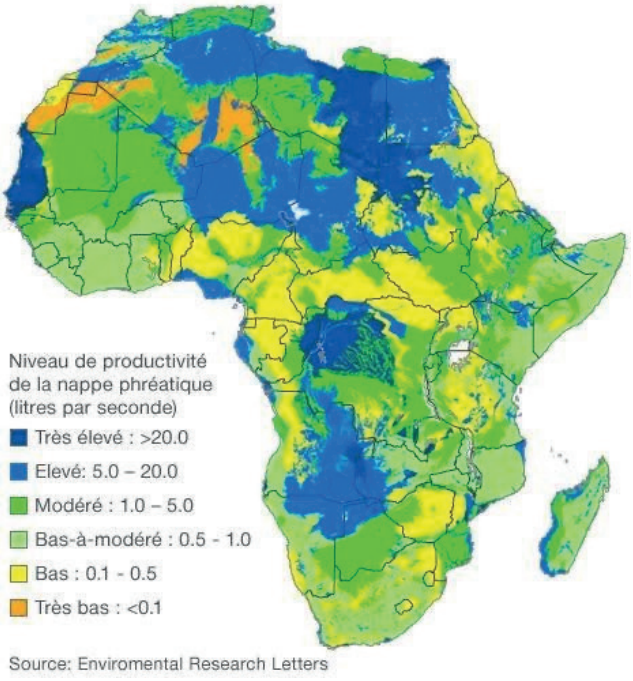

Figure 1: Productivity level (litres/second) of phreatic cover.

Additionally, companies must work together to advocate for stronger regulations and support local and regional efforts to preserve and protect shared water resources.

Conclusion

Water is a finite and precious resource that must be protected. As the Maghreb faces increasing water scarcity, it is essential that all actors—governments, businesses, and communities—work together to develop sustainable solutions. The beverage industry, in particular, must take a leadership role in promoting water conservation and stewardship. By acting now, we can safeguard water for future generations and ensure the continued vitality of both the economy and the environment in this vulnerable region.

Sustainable Future of Fruit Juice Industry: Empowering Young People as Tomorrow's Leaders

Patricia Obichukwu
CEO Best Produce International UK Ltd.

There is no doubt that fruit juice industry is increasingly focusing on sustainability to ensure its long-term viability. However, talking about Sustainable future without serious investment in capacity building the young people into leadership roles across the globe, will severely impact on any long-term viability.

This is because Young People are future leaders, and as such all stakeholders and industry experts, should be intentional in empowering and building resilient of young people, to play active role in driving the future of the industry.

The juice industry currently has been aiming on addressing Sustainable Sourcing, Climate Change impact through adopting eco-friendly practices such as using renewable energy, reducing water usage, and minimizing waste. In addition to biodegradable and recyclable packaging to reduce plastic waste and educating consumers about the benefits of choosing sustainably produced juices is essential.

Nevertheless, there are still major gaps that are hindering the transformation such as lack of full engagement of young people into the sector, transparency in supply chains, challenges of ensuring that all key stakeholders adhere to sustainable practices at every stage. There are also issues on the use of sustainable farming methods, which can lead to environmental degradation and reduced biodiversity. A significant amount of fruit juice packaging is still non-recyclable or non-biodegradable, contributing to plastic pollution. There is also a gap in consumer knowledge about the environmental impact of their choices. Therefore, more education and clear labelling are needed to guide sustainable purchasing decisions.

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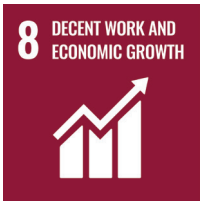
The rising global demand for fresh, organic products meant that there is possibility for significant growth for the juice sector. However, to ensure this growth is sustainable, it is crucial to invest in the empowerment of young people across all regions. The future of juice production relies not only on technological advancements but also on the active involvement and innovative potential of the next generation. As a result, all stakeholders are required to collaborate to achieve this, including industry leaders, educational institutions, government bodies, local communities and individuals.

Companies within the juice production sector play a vital role in driving sustainable practices. Therefore, by investing in the lives of young people through training and capacity building programmes, internships, and apprenticeships, they can equip them with the skills needed for modern agricultural practices and production technologies. These programmes should emphasize water efficiency, renewable energy use, sustainable farming methods, methods of analysis, processing, entrepreneurship and leadership. Furthermore, industry leaders can create platforms for young people to present their innovative ideas and projects, fostering a culture of creativity and problem-solving.

Effective Community engagement processes in empowering young people for sustainable farming practices and water conservation efforts will also ensures the long-term viability of the sector. These can promote traditional knowledge and innovative techniques tailored to local conditions. Moreover, involving young people in community projects fosters a sense of responsibility and connection to their environment, encouraging sustainable practices from the ground up and also mentoring them into leadership for sustainable future.

Effective Community engagement processes in empowering young people for sustainable farming practices and water conservation efforts will also ensures the long-term viability of the sector.

In conclusion, empowering young people is essential for the sustainable future of the juice production industry. Therefore, through collaborative efforts, we can harness the potential of the next generation to drive innovation, sustainability, and growth. By investing in their effective engagement, capacity building, providing practical training, and supporting entrepreneurial initiatives, we can ensure that the industry thrives in harmony with the environment. The time to act is now, and together, we can build a sustainable and prosperous future for the juice production industry and beyond.



Carbon Neutral: Reality or Unfair Competition?

How to correctly inform and communicate when reporting CO2 capture

Paula Dip, Head of Sustainability, Vicente Trapani S.A.

Climate change is an undeniable reality, with increasingly evident effects worldwide. Leading scientists and international organizations like the Intergovernmental Panel on Climate Change (IPCC) emphasize the urgent need for concrete measures to mitigate its impact. In this context, standards such as **VERRA** and **Gold Standard for the Global Goals**, along with organizations committed to sustainable production like **Fundación ProYungas**, play a crucial role by providing tools and methodologies to transparently quantify and verify ecosystem services and carbon emissions.

One of the current major challenges is assigning real economic value to natural resources and ecosystem services that support our economy, such as carbon capture, water cycle regulation, and biodiversity conservation—key elements in addressing the climate crisis. However, inadequate oversight and insufficient verification can distort the market, leading to unfair competition between companies that adhere to regulations and those that do not.

It is fundamental to advance towards an economy that grows without increasing the pressure on the environment while promoting a real environmental decoupling.

The Importance of Transparency in Carbon Markets

In the context of carbon markets, promoting transparency and rigorous verification of practices through formal markets is crucial. While there are various initiatives to measure and report carbon emissions and sequestration, some methodologies do not always meet the highest standards. This discrepancy can create competitive challenges and jeopardize global climate mitigation goals. Some companies may claim to be carbon neutral without solid, verifiable data. Fostering more rigorous and standardized practices is essential to ensure that climate mitigation efforts are effective and trustworthy.

Accurate in situ measurements that reflect the specific carbon stock of each ecosystem are vital, going beyond generic references that may overlook critical conditions like forest degradation. In degraded forests, carbon sequestration rates can be significantly lower than in healthy ones. To reliably assess a company's carbon removal capacity, periodic re-measurements at consistent intervals (e.g., every five years) are necessary. This approach allows for calculating the annual carbon sequestration rate and provides a reliable basis for responsible claims about carbon neutrality.

The European Law Against Greenwashing: Consumer Transparency

The new European law on **Consumer Empowerment for the Ecological Transition** prohibits the use of unproven generic claims like "environmentally friendly" or "carbon neutral" on products, as well as the marketing of products with claims of reduced environmental impact based on emission offset schemes. This law is a critical step toward protecting consumers from misleading claims and ensuring companies are held accountable for the environmental impact of their products.

Responsible Methodologies for Calculating Carbon Stock

1. Defining the Study Area

- Identify and delineate areas to be assessed: forests, plantations, conservation areas, etc.
- Use satellite maps, Geographic Information Systems (GIS), and drones to define boundaries and land characteristics.

2. Vegetation Classification

- Determine the types of vegetation present (native forests, reforestation areas, permanent crops).
- Assign a biomass-to-carbon conversion factor for each vegetation type, according to standardized and recognized tables.

3. Measuring Aboveground and Belowground Biomass

- Aboveground Biomass (woody vegetation): Measure height and diameter; identify species and assign a density value. Use specific allometric equations to convert these measurements into biomass estimates.
- Belowground Biomass (roots): Apply a standard expansion factor based on aboveground biomass.

4. Estimating Carbon Stock

- Convert estimated biomass into carbon using the assigned conversion factor.
- Calculate carbon stock in tons per hectare (tons C/ha).

5. Monitoring and Verification

- Continuous monitoring:Use satellite images and drones to update biomass changes.
- Verification: Independent certifiers audit calculations and certify carbon estimates.

6. Reporting and Registration

- Record results in international standard platforms.
- Report carbon stock and improvements in agroecological or conservation systems.

7. Carbon Offsets and Credits

- Carbon stock refers to the total amount of carbon stored in an ecosystem, certified through scientific methodologies that ensure accurate quantification.
- Carbon credits are tradeable units representing the reduction or capture of greenhouse gas emissions. To generate these credits, demonstrating additionality is essential.

Are NDVI Maps Valid?

Using **NDVI (Normalized Difference Vegetation Index)** maps is a valid tool for estimating **plant biomass** in an area but comes with limitations compared to direct measurement of **aboveground and belowground biomass.**

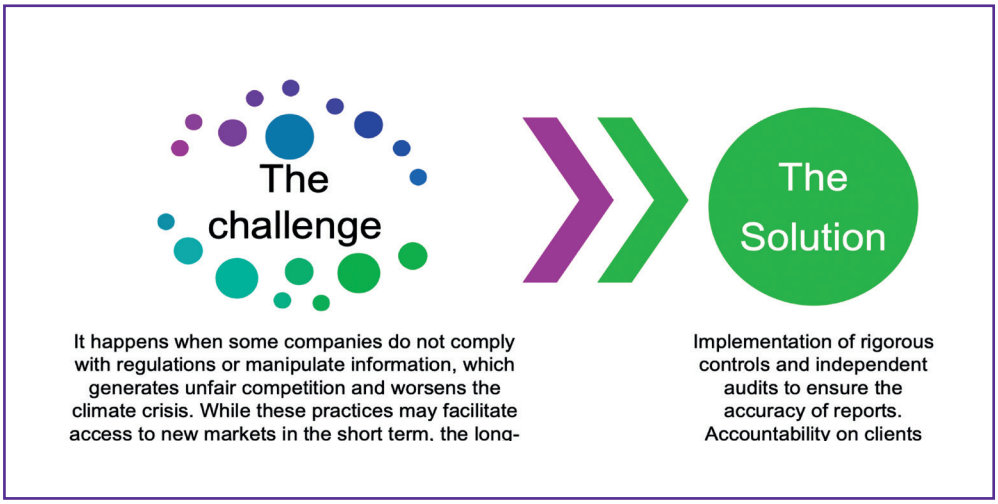
Advantages of using NDVI:

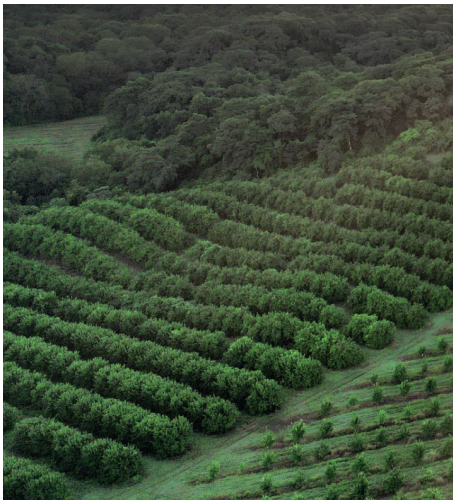
- Fast and non-invasive: NDVI uses satellite or drone imagery to estimate vegetation health and density, allowing for frequent and extensive monitoring.
- Wide coverage: It can cover large areas of land efficiently, which is ideal for large-scale projects.

Limitations:

- Lower accuracy: NDVI measures the “greenness” of vegetation, but does not provide direct information on the volume or density of biomass (either above or below-ground). This can lead to less accurate estimates of carbon stock compared to traditional biomass measurement methods.
- Does not include below-ground biomass: NDVI cannot measure roots or organic matter in the soil, which is crucial for obtaining a complete estimate of carbon stock.
- Calibration required: To be valid, the use of NDVI must be calibrated with field data (biomass measured in plots) to adjust the images and obtain more accurate carbon estimates.

In projects that follow **international standards,** it is necessary to complement with direct measurements of biomass in reference plots. NDVI images alone **are not sufficient** to obtain **certification without field verification to support the estimates.** Sample censuses will be possible when the surfaces are small, or plot-based sampling will be required, combined with remote sensing when dealing with large surfaces.





Using NDVI as a complementary tool is valid and useful, but it does not completely replace the need for direct measurements, especially if a high level of accuracy and certification or carbon credits is sought.

In this way, we will be able to move towards an economy that truly contributes to the mitigation of climate change and the conservation of the ecosystems that sustain life on the planet.

Vicente Trapani in numbers. Our commitment to climate change

1. Citrus Report (April 2024)

- **Number of plants sampled:** 750 plants.
- **Number of farms**: 5 farms (Esmeralda, Río Loro, Zuccar, Berbelux, Ruiz).
- **Total surface area:** 539.9 hectares.
- **Results obtained:**
  - Average carbon stock: 34.1 tonC/ha (125.15 tonCO2/ha).
  - Total carbon stock: 14,381 tons of carbon (52,778 tons of CO2).
  - Annual carbon accumulation rate: 1.8 tonC/ha/year (6.6 tonCO2/ha/year).

- **Medium-term projections:**

Consolidate continuous carbon monitoring and adjust carbon growth models based on the age of the plantations.

2. Forest Inventory (May 2024)

- **Number of plots sampled:** 16 plots in native forests.
- **Number of farms:** 5 farms (Esmeralda, Zuccar, Berbelux, Ruiz, Río Loro).
- **Total surface area:** 264 hectares of native forest.
- **Results obtained:**
  - Species identified: 32 species of trees and shrubs.
  - Average carbon stock: 60.94 tonC/ha.
  - Trees per hectare: 339 on average.

- **Medium-term projections:**
  - Reforestation and natural regeneration management on farms with degraded corridors, such as Esmeralda and Zuccar, to improve the carbon fixation capacity, and therefore the biodiversity of these forests.

*In a context of climate crisis, commitment to **responsible and truthful information** is essential. Companies have the opportunity and obligation to contribute significantly to the mitigation of climate change, but they will only achieve this if they base their actions on reliable data, rigorous measurements and transparency. Choosing to report correctly, verifiably and honestly not only protects ecosystems and future generations, but also builds trust and credibility in the market. **The future of our planet depends on informed decisions and a commitment to the truth.***

Carbon Footprint Calculation in Argentinean Lemon Juice Production

L. Patricia Garolera De Nucci and M. Emilia Iñigo Martínez,
Researchers at the Estación Experimental Agroindustrial "Obispo Colombres", Tucumán, Argentina

Estación Experimental Agroindustrial Obispo Colombres (EEAOC) is an government research institute based in the province of Tucumán, Argentina. This organization is structured by an "ad honorem" board of 10 representatives from several agroindustry activities and a technical Director followed by four assistant directors who supervise key operational areas, such as Agriculture Technology, Industrial Technology, Special Disciplines, and Administration and Services. Research, technical support, and services to local and regional agroindustries are the mainly responsibilities of the EEAOC. Through its recognized experience in R&D&I project management, the EEAOC contributes with technology development based on agriculture, industry, and economics topics. The sustainability of crops and their derivatives is one of the branches of the R&D&I program.

Sustainability and innovation

The EEAOC is specialized in developing methodologies and tools to facilitate the path toward sustainable agroindustry model. Through its explorations, it provides to organizations and governments the scientifically based solutions for assessing, managing, and reducing their environmental impacts. These solutions include evaluating indicators such as carbon footprint and water footprint, which are crucial to assessing and managing the sustainability of industrial processes.

These solutions include evaluating indicators such as carbon footprint and water footprint, which are crucial to assessing and managing the sustainability of industrial processes.

Together with local's citrus sector, the EEAOC elaborated a carbon footprint report for lemon fresh fruit to export and their derivatives (juice, oil, and dehydrated lemon peel) in accordance with the distinctive agronomic and industrial conditions of the region. These results show that the highest impacts are due to fossil fuel (particularly natural gas) and electricity consumption, as well as the type, origin, and usage of inputs during agricultural and industrial stages.

Innovative tools for environmental management

The EEAOC developed an innovative, user-friendly tool to enable companies to assess and improve their environmental performance in both agricultural and industrial settings. This resource includes a carbon footprint calculator that identifies opportunities to reduce emissions, optimize resource use, and foster a circular economy. Research efforts also focused on improving the environmental profile of the citrus industry by replacing natural gas with renewable fuels. The water footprint of lemons and their derivatives was also estimated under rainfed and irrigated conditions, and these studies were extended to other crops in the province.

Energy efficiency and water footprint analysis

As part of this research program, the EEAOC explored ways to save energy in the citrus industry. The results of the study demonstrated an improvement in environmental performance when natural gas was replaced with renewable fuels. In general, renewable energy sources have been shown to reduce greenhouse gas emissions by 20% to 80%, depending on the technology used and how it is implemented. In addition, a comprehensive water footprint analysis of fresh lemon fruit and its derivatives was conducted under rainfed and irrigated conditions. The study revealed that improvements in irrigation efficiency could significantly reduce the blue water footprint, both at the farm level and in the factory. This would lead to more sustainable water use throughout the production process. The results of these studies have been applied to other crops in the province, improving sustainable agricultural practices throughout the area.

In general, renewable energy sources have been shown to reduce greenhouse gas emissions by 20% to 80%

CO_2 capture initiatives in collaboration with the private sector

The EEAOC is leading a CO2 capture project in lemon plantations with the support of the citrus private sector. This project considers the importance of quantifying carbon sequestration as part of the region's climate change mitigation efforts. The ongoing trials are being conducted on farms representing different agroecological zones of the province, taking into account plantation age and rootstock-scion combinations. It is expected that these trials will yield a percentage of carbon absorption based on Argentine lemon tree characteristics comparable to international benchmarks. This will contribute to the achievement of carbon neutrality. The project involves activities such as plant selection, fruit harvesting, tree removal, biomass classification, and sample preparation for laboratory analysis at the EEAOC. Additionally, these analyses aim to create a database that can be used for the future characterization of lemon groves without the use of destructive techniques, providing a valuable tool

for sustainable management. The results will provide a robust foundation for launching carbon offset projects and promoting soil management practices that enhance carbon capture.

Future vision

The EEAOC aims to promote sustainability in local and regional agribusiness by fostering environmental awareness and developing tools to measure and reduce environmental footprints. By studying the impact of technology on economic growth, environmental conservation, and innovation, the EEAOC supports more informed decision-making for future sustainability. Through comprehensive sustainability analysis, combining environmental, economic, and social assessments, the EEAOC aligns local agroindustrial activities with international sustainability standards.

Progress in Water Footprint Reduction

Agustina Lucci, Sustainability and Innovation Director **and Noelia Lescano,** Quality and Environment Management Chief at Citrusvil, Argentina

Water resources are crucial for life in our planet and for food manufacturing. That is why Citrusvil manages water in an integrated way as part of its commitment to its efficient and responsible use by adopting the best practices and making progress in terms of its water footprint.

The company, which is located in Tucumán, Argentina, is engaged in the **production and industrialisation of lemon and its industrial by-products** and it develops **a vertically integrated business model** from the production of seedlings in its nurseries to the industrialisation and commercialisation of its by-products.

It has a long-term sustainable production system which strikes a balance between productivity and profitability and caring for the environment and the people and the communities where the company operates, guaranteeing the **supply of healthy, safe and quality-certified products** from the Southern Hemisphere to the world, destined for the beverages, flavours and fragrances industries.

Currently, it conducts its operations in **7,875 hectares of lemon plantations** distributed in 23 orchards strategically located from north to south in Tucumán, which has optimal agro-climatic conditions for the production of this fruit. In addition, the company develops its sustainable production by means of 2 lemon industrialisation plants.

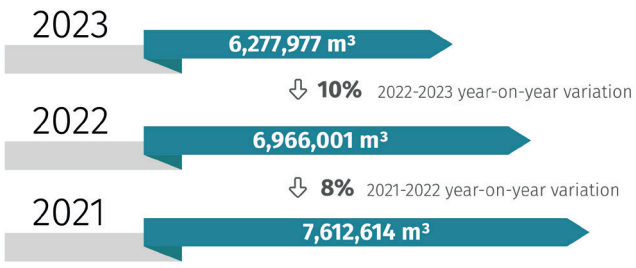
Progress in Citrusvil's Water Footprint

Citrusvil shows its commitment to reducing its water footprint in order to manage natural resources in an efficient and sustainable manner and in the context of its Sustainability Policy.

Every year, the company reports its progress in its Sustainability Report. Citrusvil's activity represents a concrete ecological change. Besides, the company shows the possibilities of sustainable alternatives for the industry through its investments, promotes them and is an innovation driving force in the province of Tucumán and in the region.

Water consumption is determined in each phase of Citrusvil's value chain by means of the "Blue Footprint" methodology, in accordance with ISO Standard No. 14,046.

Water Footprint:



For further information, read our 2023 Sustainability Report

Circular Economy Practices

Citrusvil's products are generated in a circular production chain **which aims at saving resources and contributing to nature as an active participant,** unlike other traditional industrial practices which do not take into consideration the waste generated and its consequences.

Citrusvil is Zero Effluent: all the effluent generated throughout the industrial processes is treated at its Treatment Plant. Then, the treated water is used for dripping fertigation in 600 hectares of lemon plantations, thus preventing the industrial effluent from being discharged into natural or public water sources. That is how, last year, 1,230,000 m3 of treated effluent were used for fertigating the lemon plantation in areas near the production.

Improvements in Sustainable Production

Being aware of the importance of water in all the processes, over the past year, we have implemented new practices and made new investments which aim at reducing water consumption throughout the value chain.

Main practices implemented which reflect an efficient use of water

• **In orchards:**

– Over **20 operational dams in citrus orchards,** which capture rainwater for production irrigation and prevent soil erosion.

– **45% of the citrus productive area is under dripping fertigation**

– **Mulching technique** in citrus plantations reduces the loss of water from soil by evaporation and makes the most of the organic waste generated.

– **Artificial intelligence** allows us to analyse data about the plants and soil in real time by means of weather sensors. That is why Citrusvil is conducting a research process in Colonia 1 orchard, one of its 23 orchards, in order to determine the real need of water that the production lot has. By the analysis of these data, we aim at obtaining real-time forecasts and irrigation recommendations based on plant stress, growth patterns, forecasted weather conditions and the content of water in the soil so as to **use this resource rationally by means of this innovative initiative for production.**

• **In Industry: passion for continuous improvement**

– Recovery of water streams at different stages of the process

– Optimisation of the process of fruit washing and the pumping systems

– Optimisation of the circuit of peel washing

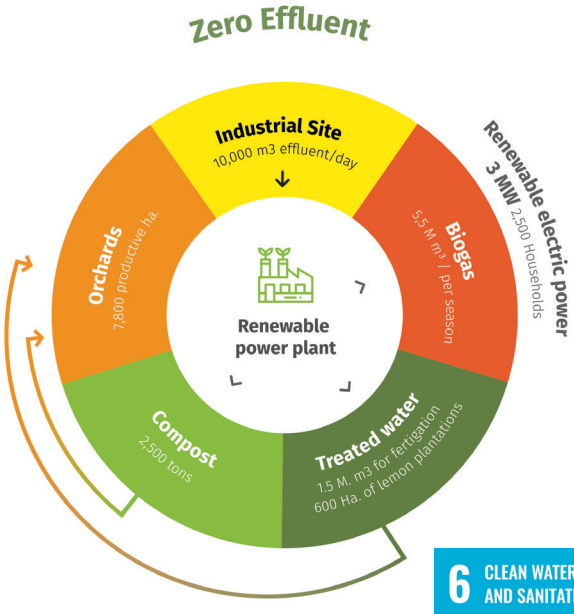
– Ongoing staff training on the rational use of water

These aspects make innovation, the company's strategic pillar, contribute to the continuous improvement of Citrusvil's water treatment.

Sustainable and innovative practices for the benefit of future generations

Citrusvil prioritises sustainability in all its processes, a commitment which led us to develop a sustainably integrated production system which results in safe and healthy food products.

Citrusvil's sustainable model inspires other companies to make strategic decisions which involve all the operations and the value chain.



Note: Being zero effluent, Citrusvil uses water efficiently, reusing the treated water for fertigation and generating renewable electric energy through biogas.

6 CLEAN WATER AND SANITATION

Orange, an Environmental Heritage

Ibiapaba Netto, Executive Director at Citrus BR, Brazil

Over the past five decades, few sectors have grown, evolved, and modernized as extensively as the Brazilian citrus industry. In a region that includes the states of São Paulo and Minas Gerais lies the Citrus Belt, currently the largest orange-producing area in the world. Across its 388 thousand hectares, more than 200 million productive trees grow on over 5 thousand properties, according to data from Fundecitrus, a research center maintained through a partnership between industries and producers. It is a sector that generates more than 200 thousand direct and indirect jobs, making Brazil the world leader in orange juice production, accounting for 75% of the global market and generating annual exports of about US$ 2.7 billion. However, the contribution of the orange goes beyond the numbers that prove the sector's importance for the economic and social development of various regions of Brazil. In recent years, the Brazilian citrus industry has proven to be an important example of environmentally sustainable production, capable of producing efficiently and productively, in harmony with nature.

Evidence of this can be seen in the rational use of land. In the 2023/2024 harvest, the area planted with oranges was 337 thousand hectares, whereas in the 1993/1994 harvest, it was 594 thousand hectares – a reduction of 43%. During the same period, productivity increased by 36%, rising from 508 to 691 boxes per hectare. In some areas the productivity reaches more than 1.5 thousand boxes per hectare. This improvement results from investments in agricultural technologies that have made production more efficient, showing that agricultural expansion can be done responsibly and sustainably. This model has allowed the citrus industry to maintain 159,629 hectares of native forest within the orchards. In other words, for every 2.89 hectares of oranges planted, 1 hectare of native vegetation is preserved. To put this into perspective, it is an area larger than the city of London, with care and maintenance carried out by Brazilian citrus growers.

In some areas the productivity reaches more than 1.5 thousand boxes per hectare.

In addition to contributing to biodiversity conservation, the citrus industry plays a fundamental role in mitigating climate change. A study conducted by Fundecitrus in partnership with Embrapa, a governmental institution, revealed that the citrus sector has a carbon stock of 36 million tons, equivalent to 133 million tons of CO_2 removed from the atmosphere – corresponding to 8 years of emissions from the city of São Paulo. These numbers reinforce the importance of the citrus industry as an ally in the fight against global warming. Orange cultivation areas are also a haven for biodiversity. The same study

identified the presence of 314 fauna species in the orchards, including 268 species of birds, 28 species of mammals, and 18 species of reptiles and amphibians. This coexistence shows that the citrus industry can offer a safe habitat for local wildlife, contributing to the conservation of biodiversity.

Another example of respect for biodiversity is the presence of bees, which are fundamental for pollination and food production and find an ideal habitat in the orange orchards. In the state of São Paulo, 84% of the honey produced originates from orange groves, and over the past 16 years, honey production in these areas has increased by 136%, according to data from Fundecitrus and the Brazilian Association of Bee Studies (A.B.E.L.HA).

The sustainable production model is not only present in the fields. In the factories, environmental care is present throughout the entire orange juice production process, starting with zero waste generation. In orange production, nothing is wasted. Besides juice, the fruit is transformed into various by-products, such as essential oils, cosmetics, chemicals, and cleaning products. Furthermore, juice factories use renewable energy from sugarcane biomass and reuse the water extracted from the oranges for cleaning and maintenance.

In the factories, environmental care is present throughout the entire orange juice production process, starting with zero waste generation.

In this way, the citrus industry demonstrates that it is possible to produce efficiently while respecting the environment and contributing to a better planet. It is a model that makes the orange a true environmental heritage.

Ecuador: Empowering Farmers through “Don Maracuyá”

Camila Tamayo and Harry Frei, Quicornac CSR Team

Building on a Legacy of Sustainability

As we reflect on our past sustainability reports, our journey has been marked by some difficulties followed by significant milestones and growth in our commitment to sustainable passion fruit farming. From our initial steps in Ecuador and Peru to our recent foothold into Vietnam, our dedication to creating value for smallholder farmers and promoting sustainable agricultural practices has only strengthened.

In Ecuador, smallholder farmers form the backbone of our passion fruit supply chain. With the “Don Maracuyá” campaign, launched in January 2024, we have made substantial strides in promoting sustainable farming practices. This initiative encompasses four key phases: technical, theoretical, experimental, and communicational.

In Ecuador, smallholder farmers form the backbone of our passion fruit supply chain.

The campaign was launched in response to the challenges observed in the field, including climatic changes and economic hardships that have plagued the agricultural sector in Ecuador. We noticed a growing disinterest

and distrust among farmers towards cultivating multiple crops, including passion fruit. Recognizing the importance of passion fruit cultivation for our farmers' weekly income and economic sustenance, we took it upon ourselves to promote and manage this vital change.

We began with a robust communication campaign to attract new farmers to passion fruit cultivation. Our technical workshops provided 65 new farmers in the Esmeraldas region, with essential knowledge on soil preparation, fertilizer application, pest control, and disease identification. Theoretical workshops followed, focusing on financial management and budgeting to help farmers maintain sustainable practices.

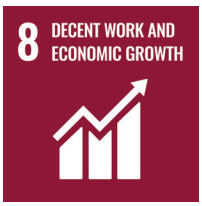
We began with a robust communication campaign to attract new farmers to passion fruit cultivation.

By mid-2024, practical workshops were conducted in real plantations, allowing farmers to practice planting techniques, pest control, and manual pollination. An experimental project aimed at improving transplant techniques from nurseries to plantations was also implemented, reducing plant stress and enhancing productivity.

The results have been promising, with up to a 50% increase in fruit yield and improved financial literacy among farmers. Mariana Garcia, a farmer from Manabí, shared her positive experience: "The 'Don Maracuyá' campaign has provided me with the technical support to better manage my crop sustainably and environmentally friendly."

Looking Ahead

Our goal remains clear: to expand our sustainability initiatives and positively impact more farmers and communities. We are excited about the future and remain committed to driving change in the passion fruit industry. We invite you to join us in this unique journey towards a more sustainable and prosperous future for passion fruit farming.



Peru: Expanding Sustainable Practices with the “Maracuchito” campaign

Camila Tamayo and Harry Frei, Quicornac CSR Team

Building on a Legacy of Sustainability

Reflecting on our sustainability journey, we’ve faced challenges but achieved key milestones, deepening our commitment to sustainable passion fruit farming. From our early initiatives in Ecuador and Peru to our recent expansion into Vietnam, our focus on creating value for smallholder farmers and promoting sustainable agricultural practices has continually grown stronger. These efforts underscore our dedication to fostering long-term sustainability in every region we operate.

Inspired by our success in Ecuador, we have recently launched the “Maracuchito” campaign in Peru, adapting it to the local realities of the region. Peru’s agricultural diversity and the role of smallholders have been instrumental in our sustainability efforts. Despite challenges such as fertilizer shortages and droughts, our agriculture team has forged strong partnerships with local farmers and certified collection centers.

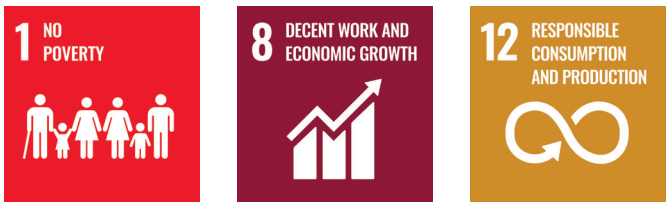
The “Maracuchito” campaign seeks to promote the cultivation of passion fruit and help our farmers identify closely with this cash crop. Passion fruit is unique in that it produces fruit every week, providing our farmers with a consistent and reliable income, whether through the fresh market in Lima or our processing facilities.

Moreover, we have implemented a sustainability campaign in Peru focused on extending Rainforest Alliance certification to more of our farmers and providing ongoing training. Our workshops address fair pricing and long-term crop sustainability, emphasizing collaboration between the industry, customers, and local communities. Our goal is to improve the livelihoods of our farmers and increase sustainable production.

Commitment to a Sustainable Future

Throughout our journey, we have learned to understand the diverse challenges our smallholders face daily. We strive to provide them with the necessary resources and support, always demonstrating our commitment to sustainable agriculture in a transparent, dedicated way. Our vision is to ensure a sustainable future by promoting global farming practices that benefit both our farmers, customers and the environment.

We warmly encourage our stakeholders to support and engage with these initiatives, ensuring the future of passion fruit farming remains bright and prosperous.



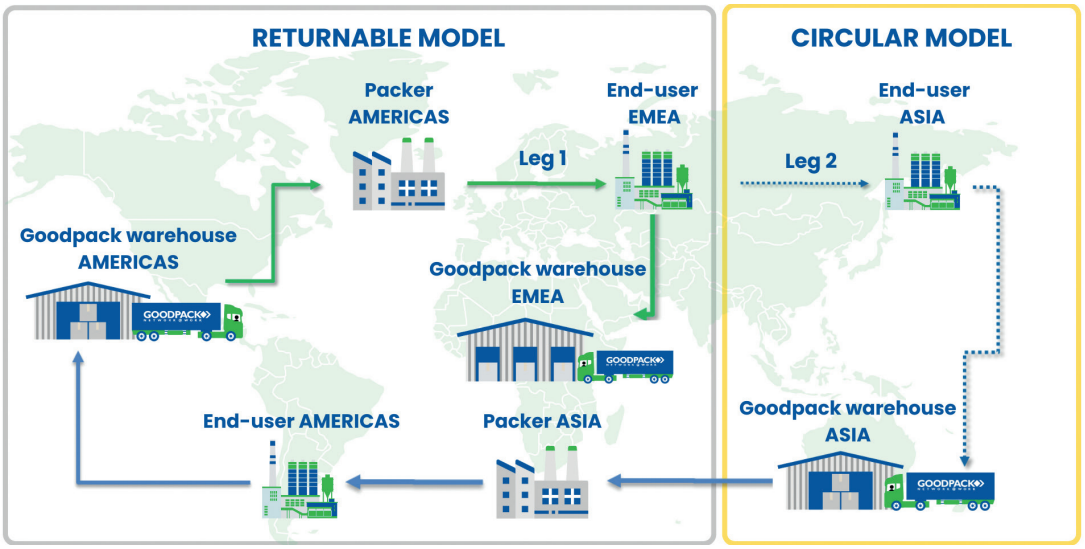
Data-driven Decarbonisation

George McFarlin, Quinie Lim and Lakesh Rengarajoo,
Sustainability Committee-Goodpack IBC

Goodpack's reusable packaging and Carbon Calculator uses data to drive supply chain efficiency and carbon footprint reduction through its circular supply chains

As companies decarbonise their supply chains, one of the major challenges is tracking and reporting its Greenhouse Gas Emissions, especially once the packaging leaves their control With decarbonisation commitments and corresponding initiatives such as Scope 3 emissions accounting, which are being used in corporate climate disclosure policies, it becomes critical to be able to measure the carbon footprint through the entire supply chain. In this article, we look at how packaging can support decarbonisation efforts and how our Carbon Calculator can provide quantifiable data to drive, track and report carbon reductions.

Goodpack's circular supply chain model, is built on the reuse, repair and recycle process and designed to drive businesses towards building more efficient, resilient and sustainable supply chains. The model encompasses the delivery and collection of our Intermediate Bulk Containers (IBCs) to and from our customers, using a global network of local depots spanning 80 countries and over 5,000 collection and delivery points. For even greater cost and carbon efficiencies, containers can be reused by the company receiving product for their outgoing product, without the need for return trips to a Goodpack depot in between.



An Illustration of what a circular supply chain for packaging looks like

While the benefits of Goodpack's model could be qualitatively explained (reusable packaging, reduced distance travelled due to higher network density and high load factors etc), this approach does not support the users with

1) A clear understanding of the actual impact on their organisations carbon footprint and other impact categories

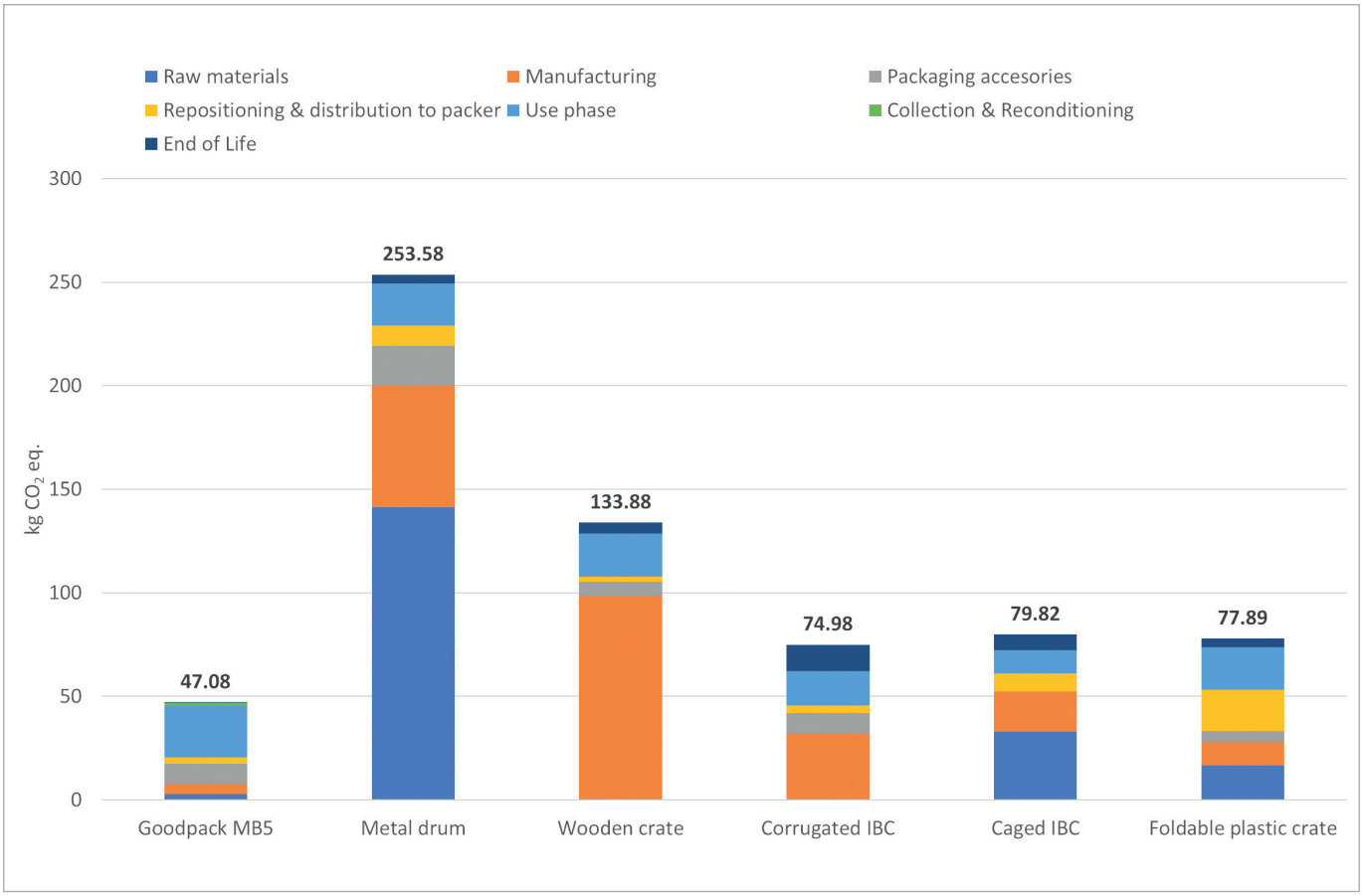
2) Support for Greenhouse Gas Reporting, particularly regarding Scope 3 emissions and the challenges companies face when reporting and reducing them

3) Driving improvements to decarbonise such as understanding payload optimization and packaging sourcing.

A Carbon Calculator that provides numbers to drive decision making and support reporting

Goodpack's carbon calculator is built on the back of a Life Cycle Impact Assessment, consistent with ISO 14040:2006 and 14044:2006 and put through an independent review in line with ISO 14071:2014. Goodpack uses an environmental impact calculator that provides users of its packaging solution to identify the impact of its footprint on the entire supply chain. It takes a robust approach in considering various parameters, including manufacturing of the packaging, distances travelled, payload weight during use, and end of life when it computes the environmental impact of the solution. We use the following illustration.

Results of Global Warming Potential (GWP in kg CO2 eq) for each packaging solution used for the transport of Apple Juice Concentrate from China to the USA



Goodpack MB5 presents the lowest impact on GWP, emitting approximately 64% less CO2 eq. emissions than wood and 81% less CO2 eq. emissions than steel drums. These significant reductions are primarily due to two key characteristics of the MB5:

Reusability, which reduces the impact on raw materials, manufacturing and the end-of-life stage.

Product design, which allows for loading efficiency during ocean and land transportation. The collapsible design allows for maximum loading efficiency in sea containers and trucks when full, and optimizes space when empty.

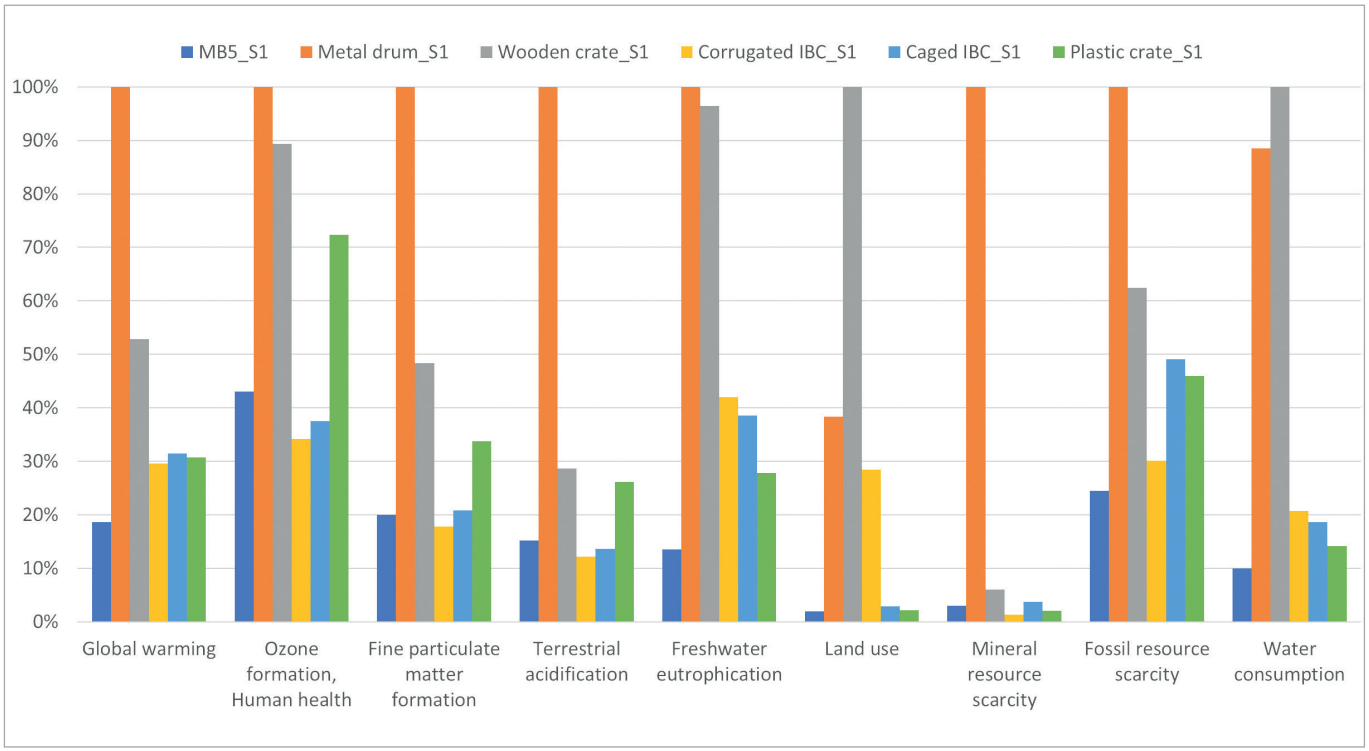
About Goodpack

Established in 1980, Goodpack is the world's leading supplier of reusable pallet-sized intermediate bulk containers (IBCs). Goodpack's innovative pay-per-use model leverages an extensive global network exceeding 5,000 delivery and collection points, ensuring efficient deployment of over 4 million containers.

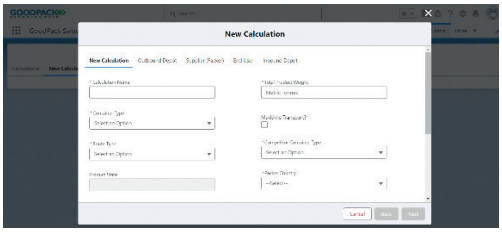
Goodpack IBCs ensure compatibility with various transportation methods (road, rail, and sea) and optimizes space utilization within standard shipping. Goodpack IBCs are reusable, reducing the use of single-use packaging with a robust metal construction that exceeds over 30 years of service life.

www.goodpack.com

The model goes beyond more than Global Warming Potential (CO2) by considering a total of 9 industry-specific impact categories. These include Ozone formation, human health, and land use, fossil resource scarcity and water consumption amongst others.



An illustration of what the tool and its outputs look like can be found below:



Calculation Name - Singapore India Trade Lane-clone
Calculation Date(DDMMYYYY) - 29052024
Product Name - Synthetic Rubber
Product Volume(Metric Tonnes) - 2,079
Tradelane - (From Singapore To India)
Goodpack Solution - MB5 for solids
Competing Solution - Metal crate

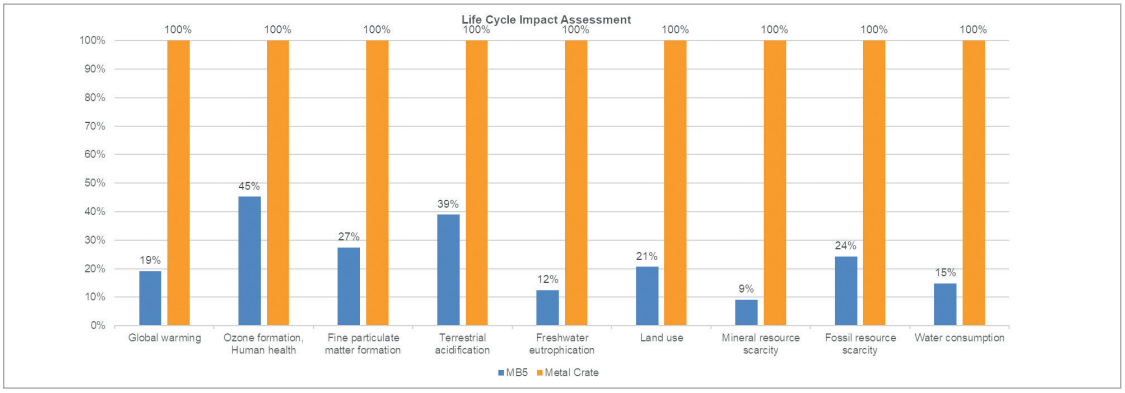
Goodpack Solution

Impact category	Unit	Total	Raw materials &	Packing &	Distribution to	Use phase	Collection &	End of life
Global warming	kg CO2 eq	31,736.79	15,088.68	4,815.43	170.52	11,091.28	512.95	57.93
Ozone formation, Human	kg NOx eq	257.76	38.25	11.48	1.91	200.97	4.91	0.24
Fine particulate matter	kg PM2.5	95.85	25.77	6.17	0.42	62.04	1.38	0.07
Terrestrial acidification	kg SO2 eq	255.23	45.56	13.55	0.81	191.67	3.53	0.12
Freshwater	kg P eq	8.73	6.85	1.37	0.01	0.45	0.05	0.01
Land use	m2yr crop	678.12	332.92	147.47	1.08	154.26	39.81	2.58
Mineral resource	kg Cu eq	538.61	504.47	8.04	0.28	22.20	3.48	0.14
Fossil resource scarcity	kg oil eq	9,774.28	3,602.29	2,823.25	50.63	3,137.79	140.92	19.40
Water consumption	m3	162.79	106.71	39.03	0.17	11.91	4.87	0.11

Competitor Solution

Impact category	Unit	Total	Raw materials & Manufacturing	Packing & accessories	Distribution to Packer	Use phase	Collection & Reconditioning	End of life container
Global warming	kg CO2 eq	163,911.08	153,900.39	1,279.69	119.90	7,822.79	235.95	552.36
Ozone formation, Human	kg NOx eq	539.10	389.19	3.04	1.34	141.39	2.05	2.11
Fine particulate matter	kg PM2.5	328.94	282.28	1.64	0.29	41.55	0.51	0.68
Terrestrial acidification	kg SO2 eq	613.31	471.97	3.60	0.57	134.54	1.02	1.61
Freshwater	kg P eq	70.59	69.81	0.36	0.09	0.31	0.03	0.07
Land use	m2yr crop	3,616.17	3,414.15	39.13	0.76	107.78	25.71	24.64
Mineral resource	kg Cu eq	5,921.01	5,901.33	2.13	0.15	15.54	0.48	1.34
Fossil resource scarcity	kg oil eq	40,075.14	36,818.72	751.39	35.60	2,213.89	70.59	184.95
Water consumption	m3	1,108.32	1,084.69	10.40	0.12	8.35	3.75	1.00

With a robust methodology and quantifying its Global Warming Potential and other impact categories, the calculator empowers users to understand the environmental impact of packaging solutions in question, enabling them to make informed choices and track of their supply chain footprint.



A Commitment to Sustainable Agriculture and Quality in Turkish Operations

Ozgehan Gundez, Head of Business Unit PBN, Döhler and
Nur Altug, Head of Analytical Science, Döhler

In today's world, sustainability is not a trend—it is a necessity. At Döhler, we are deeply committed to integrating sustainable practices into every level of our Turkish operations, from raw material sourcing to final product delivery. With an annual consumption of 700,000 tons of raw materials, our responsibility to the environment and society through these operations is paramount.

Our sourcing strategy in Turkey is based on close partnerships with local suppliers and farmers, ensuring that our operations support not only business growth but also local communities and ecosystems. To facilitate the flow of these raw materials, we have partnered with **Konfrut AG**. This collaboration, along with our advanced **Fiber-K** system, ensures that the raw materials

we use are transported efficiently, with minimal environmental impact. By optimizing logistics and reducing waste, the **Fiber-K** system has enabled us to achieve a 10% increase in transportation efficiency, significantly reducing fuel consumption, emissions, and resource use. This contributes to lowering our carbon footprint, minimizing environmental disruption, and ensuring that our materials are sourced and delivered responsibly and sustainably across our Turkish operations.

Supporting Sustainable Farming Through Contract Agriculture

A core element of Döhler's sustainability strategy in Turkey is our investment in **contract farming** and **sustainable agriculture.** By establishing long-term relationships with Turkish farmers, we provide them with the support, tools, and training necessary to transition to eco-friendly agricultural practices.

Our contract farming model helps farmers improve their yields and income while promoting practices that protect biodiversity, preserve soil quality, and reduce water usage. As part of this model, we are piloting advanced agricultural technologies that provide farmers with real-time data on crop health, soil conditions, and water management, enabling them to make informed decisions that enhance sustainability. Additionally, through our collaboration with **Konfrut AG**, we have implemented a comprehensive traceability system that tracks raw materials from farm to final product. This system not only ensures the integrity of our supply chain but also gives our farmers and partners a clear view of the entire production process, reinforcing our commitment to transparency and sustainability.

We believe that sustainability in agriculture is the key to the future of food production. By encouraging the use of organic methods, promoting crop diversification, and reducing reliance on synthetic fertilizers and pesticides,

we are helping to create a resilient agricultural system in Turkey that can thrive in the face of climate challenges.

“Our partnership with farmers is the backbone of our sustainability efforts in Turkey. By investing in their future, we invest in the future of our planet. Sustainable farming is not only good for the environment but also for the communities we work with,” says **Ozgehan Gunduz,** Head of Business Unit at Döhler.

Quality Control and Traceability: DIAL Lab’s Role in Ensuring Sustainable Standards

At Döhler, sustainability does not stop at sourcing. Our commitment extends to ensuring that all materials and products within our Turkish operations meet the highest standards of quality, safety, and traceability. This is where our state-of-the-art **DIAL laboratory** in Turkey plays a critical role. Every batch of raw materials that comes through Döhler is rigorously tested and mon tored by our expert team at DIAL Lab, guaranteeing compliance with both environmental and safety stan ards.

“Our approach at DIAL Lab is holistic. We don’t just test for quality; we track parameters related to both sustainability and product safety. Through our traceability system, we work directly with suppliers to further reduce the environmental impact of our materials, ensuring they meet our high standards for sustainability and safety” says **Nur Altug**, Head of Analytical Science. The DIAL Lab in Turkey is not just a quality control hub; it is a center for innovation. By staying at the cutting edge of food safety technology, the lab allows Döhler to maintain its global leadership in sustainable and ethical food production. The rigorous testing ensures that every product that leaves Döhler is of the highest quality, safe for consumers, and produced in an environmentally responsible manner.

Global Impact: Exporting Sustainability from Turkey

Döhler’s sustainability journey in Turkey does not end with raw material sourcing and product testing. As a global exporter, we have the responsibility to ensure that our products not only meet international standards but also set an example for sustainable production across the industry. Our in-house testing at **DIAL** guarantees that our products, from fruit preparations to plant-based ingredients, meet global sustainability certifications.

We take pride in being able to export to markets worldwide while maintaining our commitment to ethical sourcing, environmental protection, and sustainable farming. In addition, Döhler is continuously improving our own processing operations by enhancing energy use efficiency, shifting towards renewable energy sources, and optimizing water usage. By integrating these advancements, Döhler ensures that our production methods are as sustainable as the raw materials we source. We believe that by focusing on sustainability, we can offer more than just products—we can offer solutions that promote a healthier planet.

A Future-Driven by Sustainable Practices in Turkey

At Döhler, our dedication to sustainability is woven into every aspect of our Turkish operations—from our partnerships with farmers to the rigorous testing in our DIAL Lab and our global export reach. As we continue to grow, so too does our commitment to leaving a positive impact on the environment and the communities we serve.

“Our vision for the future is clear: sustainability is not an option, it is a responsibility. We will continue to innovate, collaborate, and lead the way in sustainable food production through our Turkish operations,” says **Ozgehan Gunduz,** reflecting on Döhler’s broader goals.

Looking ahead, Döhler remains steadfast in its pursuit of sustainable solutions that will not only shape the future of the food industry but also contribute to a more sustainable and equitable world through our Turkish operations.

Vietnam: Adapting to Market Demands and Climate Change

Camila Tamayo and Harry Frei, Quicornac CSR Team

Building on a Legacy of Sustainability

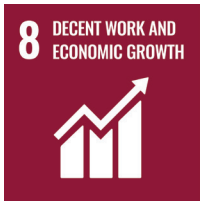
Our sustainability journey has been defined by overcoming challenges and achieving significant milestones, further solidifying our commitment to sustainable passion fruit farming. Beginning with projects in Ecuador and Peru and now expanding into Vietnam, we have consistently focused on empowering smallholder farmers and fostering sustainable agricultural practices. These efforts reflect our long-standing dedication to promoting long-term environmental and social well-being in every region where we operate, ensuring a positive impact on both people and the planet.

Vietnam's central highlands, with their favourable soil and climate conditions, offer great potential for passion fruit farming. The region's passion fruit industry is primarily supported by three key markets: the domestic fresh market in Vietnam, substantial fresh fruit exports to China and Europe, and a large-scale number of juice processing factories.

Recently, however, our farmers in Vietnam have faced significant challenges due to low average market prices resulting from a bumper crop in 2023. This downturn is largely attributed also to decreased demand for high-grade export fruit, leaving our farmers in a difficult position with lower average industrial fruit prices. Recognizing these challenges, we have taken proactive steps to support our farmers and sustain our cultivation efforts by providing them with key indicators on market demand and crop projections.

To address these issues, we collaborate closely with local agricultural departments, cooperatives, and media to emphasize the potential of our passion fruit industry and the growing global demand. We have been working diligently with our farmers to energize their cultivation by providing resources and training for best practices. Additionally, we have launched a campaign to increase our FSA-certified passion fruit famer base, which incentivizes not only sustainable farming practices but better overall pricing.

Our approach ensures year-round fruit purchases, offering stability and support to our farmers specially during challenging cycles. By promoting sustainable agriculture, we aim to enhance the resilience of our farming practices and secure the future of our passion fruit industry.



Rethinking Fruit Cultivation with Regenerative Agriculture

Christiane Hörmann, Sustainability Analyst, AUSTRIA JUICE

Climate change and biodiversity loss pose significant challenges for both agriculture and the juice industry. Extreme weather events like drought and late frosts, as well as pest infestations, are causing declining yields. Additionally, soil overuse in intensive farming has led to soil depletion and biodiversity loss, reducing fertility and making crops more vulnerable to environmental stress. This situation forces many farmers to abandon their farms, as younger generations see little economic future in agriculture under these conditions. With increased pest pressures, the interest in farming continues to decline, ultimately impacting the entire supply chain and threatening the availability of raw materials for juice production.

With increased pest pressures, the interest in farming continues to decline, ultimately impacting the entire supply chain and threatening the availability of raw materials for juice production.

Given these challenges, the question arises: How can we ensure that farming remains both sustainable and economically viable in the long term? Regenerative agriculture offers a promising hybrid approach, combining the benefits of organic and conventional farming, with a strong focus on soil health.

What Does Regenerative Agriculture Mean?

At AUSTRIA JUICE, regenerative agriculture means fostering healthy soils to ensure long-term, high-yield orchards. A key element of this approach is building up humus, the dark, nutrient-rich top layer of soil formed from decaying plant matter, which not only enhances soil fertility but also sequesters CO_2 from the atmosphere. Humus-rich soil stores water more efficiently, making it more resilient to droughts. By providing the soil with only what it truly needs through targeted fertilization, we support nutrient availability without overburdening the ecosystem.

Biodiversity also plays a crucial role in regenerative agriculture. In orchards, for example, active inter-row greening can enhance nutrient uptake while creating a vital habitat for beneficial organisms and pollinator populations. This helps control harmful insects naturally and ensures a steady food supply for pollinators like bees. As a result, more pollinators are available during fruit flowering. A stable ecosystem, combined with healthy soils, leads to more resilient trees, reducing the need for pesticides.

Up to 60% Fewer Pesticides with Resistant Apple Varieties

AUSTRIA JUICE embraced regenerative agriculture as early as the 2000s. In collaboration with the Federal Research Institute for Cultivated Plants in Dresden-Pillnitz and the University of Budapest, we developed robust apple varieties resistant to various plant diseases and pests. These varieties require up to 60 % fewer pesticides, helping to preserve soil health and biodiversity.

To ease farmers into cultivating these resistant varieties, we introduced an attractive program: the trees are provided free of charge, and farmers repay the investment in the form of apples once the trees become productive, with ongoing seasonal guidance from our agronomists. This approach reduces initial costs for farmers and fosters a long-term partnership through contracts designed to last 25 years.

Thanks to this approach, we have planted 3.5 million trees in Hungary and Poland. Since 2017, our contract

farmers have also participated in the "Farm Sustainability Assessment," an independent third-party verification that ensures sustainable farming practices.

The Future of Farming Depends on Healthy Soils

Healthy soils and sustainable cultivation methods are the cornerstones of long-term agricultural productivity and profitability. Therefore, as soil is a complex ecosystem, practical knowledge is essential. That's why we see it as our responsibility to support farmers in this process. As a next step, we have established an experimental orchard under scientific guidance to better understand what the local ecosystem needs and to demonstrate the principles of regenerative agriculture in a hands-on way.

We have established an experimental orchard under scientific guidance to better understand what the local ecosystem needs and to demonstrate the principles of regenerative agriculture in a hands-on way.

In times of changing environmental conditions and increasing stress on ecosystems, it is essential that we support farmers in overcoming these challenges to ensure their long-term economic viability. Promoting regenerative agriculture is a key element in this process, helping to maintain healthy soils and biodiversity, which are crucial for securing sustainable yields and the raw material supply for the juice industry.

AUSTRIA JUICE

Effects of Climate Change on Peach Cultivation in Central Macedonia, Greece

Eleni Marabouti, QA & Sustainability Manager, ASPIS SA

Climate change[1] in Greece and the Mediterranean basin

- The Mediterranean Sea is warming 3 times faster than the oceans and the area is classified as a point of high intensity and danger.
- Greek agriculture (and that of the Mediterranean) is characterized as vulnerable, due to water deficits, the irrational management of water resources, due to the serious effects but also the need to adapt to climate change, with an emphasis on extreme weather events.
- The total annual precipitation is predicted to decrease in Greece by 5-25% towards the period 2041-2070 and by 10-40% towards 2071-2100
- Indices related to maximum daily near-surface temperature are expected to increase markedly in spring and summer. Increased heat stress and water deficit are expected to have negative effects on crops, while a reduction in frost days may have positive effects.
- In Greece, there have been significant upward trends in the average annual temperature, which may affect the availability of water for agricultural use in the near future.
- The redistribution of water within Mediterranean basins due to climate change will have serious consequences for irrigated agriculture, industry and domestic water use in the region

Peach production in Greece

Peach is one of the most important crops in Greece, after olives and citrus fruits. On average 66% of the cultivated area with peach trees in the European Union belongs to Spain and Italy. Greece is in 3rd place with approximately 24% and 370,000 acres. (USDA, OPEKEPE)

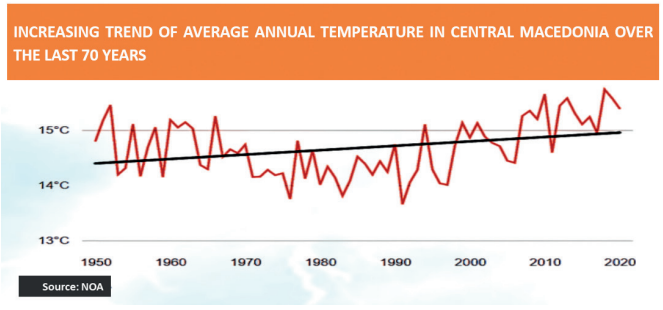
Greece occupies a leading position in the world market in exports of processed canned products and with significant exports of peach juice. (OEC: Observatory of Economic Complexity).

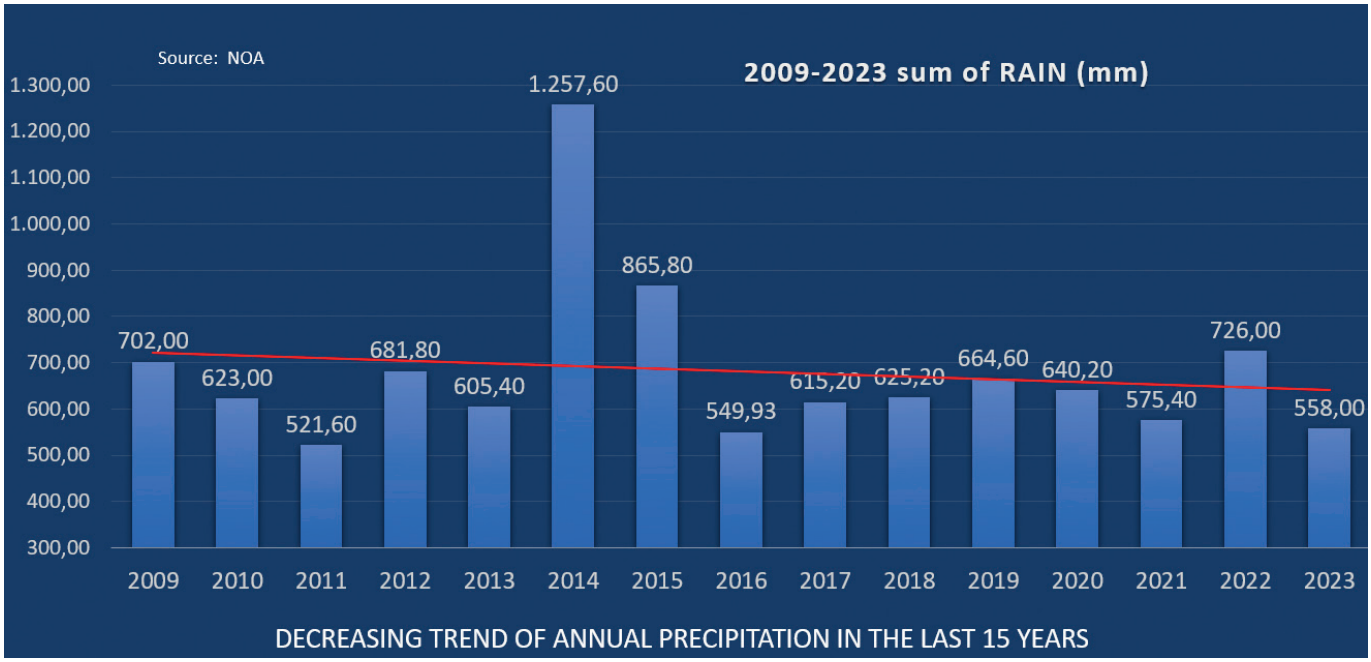
The importance of canned clingstone peaches for Greece

In the cultivation of canned clingstone peaches, Greece is occupying the first place as an exporter of peach compote, namely 45% of world exports and the second place as a producer worldwide. In the last 5 years, cling peach for canning cultivation has remained at approximately the same level in terms of areas (190,000 hectares), with production showing large fluctuations due to climatic conditions (lowest year in 2021 with 275,000 tons and best in 2022 with 450,000 tons).[2]

Central Macedonia is an important region for the production of agricultural and livestock products in Greece. Especially for peach cultivation, this started systematically in the 1960s. and about 85% of the total cultivated area is located in the regions of Imathia and Pella. This contributes to offer jobs to 10.000 farmers and about 15.000 workers in processing factories, contributing greatly to the local economy.

Climate change in Central Macedonia





Impacts of climate change on peach cultivation

Statistically significant changes in the average annual temperature (increasing trend) are observed, but also changes in the annual amount of precipitation (decreasing trend).

The region is already experiencing temperature-related crop damages, changes in rainfall patterns, increasing frequency and intensity of extreme weather events (floods, hailstorms, heat waves, droughts, etc.)

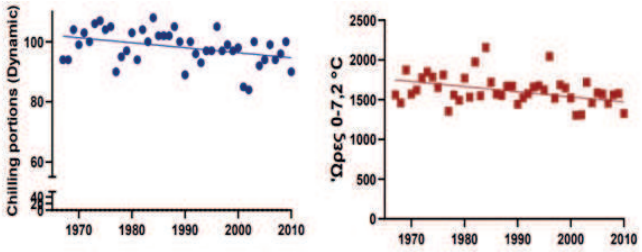
Peach fruit chilling requirements

- Buds have specific chilling requirements. If they are covered, uninterrupted, a regular production is ensured every year.

- Buds are capable of accumulating hours at temperatures between 0 and 7.2 °C (active temperatures). Temperatures above 16 °C remove accumulated cold hours, while temperatures < 0 °C add no hours to this biological clock.

- Chilling hours requirements vary with variety. Most clingstone varieties cultivated are relatively demanding.

- The severity of the effects on productivity and fruit quality depends on how well chilling requirements were met.



Clingstone peaches cvs A37: Left normal production (Imathia-May 2022).

Below: atrophic fruits and unfruitfulness due to insufficient chilling requirements (Imathia-Early May, 2023).

Left: Deformed fruits. Unequal maturation and reducing quality and yields.

Below: Delay in flowering and blastophore development buds, resulting in fruits of different sizes on the same branch.

Source: Institute of Plant Breeding and Genetic Resources - Hellenic Agricultural Organization- Department of Deciduous Fruit Trees

Effect of high temperature during flowering

The duration of receptivity of the stigma, the germination of the pollen, the growth of the pollen tube as well as the fertility of the spermatoblasts are affected.

Effect of increase temperature and reduction of rainfall

- Shortening of the growth cycle from flowering to ripening of the fruits, disturbances in photosynthesis adversely affecting the quality and the duration of storage of the fruits.
- Rising temperatures can affect the differentiation of flowering buds in summer leading to reduced yield the following year
- Excessive growth can create dense trees, reducing aeration and favoring disease.
- Increased evapotranspiration of the plant parts which increases the water needs and the cost of irrigation which, combined with a possible decrease in rainfall but also in the availability of irrigation water in the future, the problem is maximized.
- The effects of changes in temperature and rainfall on yields can be either direct on tree growth or indirect, creating favorable conditions for diseases and pests, changes in soil quality, changes in the adequacy of water availability.

Effects on fruit quality

A large percentage of fruits with (pit split in the CATHERINA variety due to intense fruit failure in 2023. The consequences are serious in canning but also in the post-harvest strength of the fruit.

Extreme weather events in Central Macedonia

A weather phenomenon is characterized as extreme when it is far from the average, that is, that which is usual in a region and regardless of the effect on life or the ecology of the Earth.

Large fluctuations in temperature, sharp variations in precipitation, frequent episodes of precipitation with great rapidity, more frequent occurrence of severe and extreme phenomena (superstorms and cyclones) phenomena that were very rare in the past, are strong indications of the coming climate changes.

The humidity can create suitable conditions for the development of diseases - the growth of pathogenic organisms. In the photo, Monilinia sp. in the ANDROSS peach variety shortly before their harvest after a heavy precipitation three-day in the region of Alexandria Imathia in August 2022.

- Prolonged rainfall and very wet weather during the flowering stage is an inhibiting factor for successful pollination and fruit set (reduced production).

- With high RH (relative humidity), the anthers do not split and with the rain, the pollen is carried away and lost, thus negatively affecting fruit set.

- Both the opening of the anthers and the amount of pollen as well as its transfer are limited.

Destruction of peach production in the Imathia region after supercell in July 2019

Total destruction of peach production in the Imathia region after supercell in July 2019

Destruction of peach production after a strong hailstorm in June 2022.

Problems due to prolonged heating. On the left are sunburned - "wrinkled" skin fruits and on the right from the difficulties during harvesting when we have a large variability in the ripening of the fruit. These phenomena are accelerated if a wet rainy season precedes.

CLIMATE CHANGE ADAPTATION

- Changes in climate indicators and extreme weather events due to climate change directly affect the crop both in terms of productivity and fruit quality.
- Directly in the biochemical functions of the plant and indirectly by modifying the environment of the orchard which in turn affects the growth of the trees.
- It can cause possible future changes in the geographical distribution of the crop, changes in the dynamics of enemies and diseases, emergence of new pests of warmer regions, more resistant - more competitive weeds.
- Difficulties in implementing cultivation operations at the appropriate stage of development of the programs: plant protection, irrigation, thinning, etc., insurmountable difficulties in the quality harvesting of fruits by the workers on the farms. and an increase in cultivation costs (irrigation, plant protection, harvesting, extraordinary damage to plant capital and equipment, reduction or loss of annual production, etc.)
- The increased cost of production as well as the possibility of changes in the geographical orientation of the crop underline the urgent need for further development of research and the adoption of adaptation strategies to increase the resistance of the specific species to the effects of climate change and to maintain the competitiveness and sustainability of the industry sector and canning.
- The adaptation of cultivation to climate change must be collective, with collaborations (State, scientific bodies, farmers, industry, etc.), for the development and implementation of effective strategies to deal with or mitigate the effects.
- The challenges are great in terms of the effects on yields, on the quality of the products produced, on the plant capital, on maintaining the existing geographical orientation of the crop (IMATHIA-PELLA) and with the particularities of the canned peach varieties cultivated today.

ASPIS produces a great variety of fruit juices and purees, aromas and oils, fruit preparations and canned products. We operate with processing plants in two different regions in Greece. One is in Southern Greece in Argolis region and the second one in northern Greece in Imathia region.
Study conducted by the Sustainability Team of ASPIS on March 2024

1 The United Nations Framework Convention on Climate Change (UNFCC) defines climate change as a change which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and an addition to natural climate variability observed over comparable time periods.
2 Conclusions at the 15th World Congress of Peach Producers and Processors (Pelotas, Brazil, 2023)

EU Deforestation Regulation (EUDR) and its Impact on the Juice Industry

Klaus Heitlinger, Managing Director at the Association of the German Fruit Juice Industry (VdF).

On June 29, 2023, the EU Deforestation Regulation (EUDR) officially came into effect, marking a significant step towards sustainable sourcing and deforestation-free supply chains. The EUDR will replace the existing EU Timber Regulation. It defines “deforestation-free” products as those grown on land not deforested after 2020. As the transition period continues, the regulation is set to fully enforce, by December 30, 2024 *, the requirement that products such as cocoa, coffee, soy, beef, palm oil, rubber, and wood must be sourced from verified deforestation-free production. Market participants, including agricultural producers, importers, and large traders, will be required to comply by 2025, submitting due diligence declarations supported by GPS-based evidence to ensure compliance.

Given the implications of this regulation, many industries are assessing their involvement, including the fruit juice sector. In particular, the juice industry must consider the EUDR’s focus on packaging materials made from wood. According to the regulation, certain wooden products, such as pallets, crates, and other load carriers, will be subject to due diligence obligations unless they are used purely to support, protect, or transport another product. Empty wooden pallets, however, are currently included within the scope of the regulation, which poses challenges for supply chain operations.

The potential shift from wooden to plastic pallets, should no resolution be found, raises concerns about environmental trade-offs. While plastic may offer a short-term solution, it conflicts with broader sustainability goals, highlighting the need for a long-term, eco-friendly alternative.

As 2025 approaches, the juice industry must adapt to the evolving regulatory landscape. Compliance with the EUDR will require a transparent and traceable supply chain, particularly for packaging and transport materials. Our industry association will continue to monitor developments closely and provide updates to ensure all stakeholders are prepared for these changes, promoting both regulatory adherence and sustainable practices.

* European Commission President, Ursula von der Leyen, confirmed a one-year delay to the EUDR on Wednesday (2 October). It was originally due to start being enforced from 30 December 2024 for large businesses, and 30 December 2025 for micro and small businesses.

A Holistic Approach to Sustainability; From the Field to the Plant

Silvie Navarrete, Sustainability Manager
SVZ International

At SVZ, sustainability is a cornerstone of our operational philosophy and core values. Our sustainability strategy is founded upon three key pillars: Sustainable Agriculture, Efficient Operations, and Valuing People. These pillars guide our sustainability initiatives across the value chain. With over 150 years active in the value chain, we recognize the necessity of proactively addressing sustainability concerns in our supply chain on both fronts, at plant and farm level. By staying ahead of the curve, we not only meet but anticipate the evolving needs of our customers, ensuring that our operations remain aligned with the highest standards of sustainability.

Empowering Polish farmers through our certification programme

Through our SVZ Farmers Fund, we are deeply committed to supporting our Polish farmers achieve Silver SAI Farm Sustainability Assessment (FSA) Certification. This program is not just about meeting SAI FSA standards, it is about going above and beyond to equip farmers with the

necessary knowledge and resources they need to thrive sustainably, protect soil health, and secure their livelihood for the future.

Between 2023 and 2024, we reached 1.800 fruit and vegetable farmers in Poland through this programme. As a result, in 2023, 74% of our core ingredients and 68% of our entire portfolio were sustainably sourced. Notably, over 80% of our Polish carrots and nearly 70% of our red currants were sustainably sourced.

We have a dedicated team in Poland supporting farmers through every step of their SAI FSA certification process. In this process, we work with farmers from scratch -filling in their self-assessment questionnaires and all the way to independently sponsoring any associated costs.

We prioritize and maintain long-term relations with our farmers because we know it takes time and consistent effort to see positive results. Take for example, we source root vegetables, like carrots from Poland. These vegetables are nutrient-intensive and can quickly deplete soil quality. Thanks to our long-standing relationships with our farmers, we can actively support farmers in maintaining and enhancing soil health by supporting practices that improve organic matter levels and ensure sustainable cultivation for future harvests.

Investing in sustainable technology in our Belgium processing site

Our commitment to sustainability extends beyond the fields to our plant operations. Recognizing the importance of reducing CO2 emissions, in 2022, we acquired a new, eco-friendly pasteurizer for our Belgium plant.

This state-of-the-art pasteurizer features an integrated energy recovery system, enabling us to recover and reuse heat. As a result, so far, we have achieved a 19% reduction in CO2 emissions at our Belgium plant, compared to our 2019 CO2 baseline. Additionally, this investment has enhanced our processing capacity and efficiency, demonstrating our dedication to sustainable innovation and operational excellence.

A holistic approach to sustainability

At SVZ we understand that to achieve a truly sustainable food production system it requires a holistic approach. Our efforts in certifying farmers and investing in sustainable technology reflect our unwavering commitment to sustainability and our commitment to drive positive change across our industry through our sustainability pillars. But that's not all, we look forward to building up on these successes, exploring new opportunities, and enhancing our sustainability efforts even more

UK: Tackling Plastic Waste and Food Byproducts

David Berryman, IFU Sustainability Working Group Chair

In 2016, Japanese Scientists, investigating a recycling site, isolated bacteria which could break down PET plastic making plastic bottle disintegration possible. Since then, the enzymes responsible for the digestion of plastic have been isolated. The vital enzyme which catalyses the first step in the digestive process has been named, appropriately, PETase by Professor John McGeehan of Portsmouth University. PETase is the result of a natural mutation, but Professor McGeehan has now been able to engineer an even better version. But the discovery kick-started a revolution in research into enzymes and how they could be used not just to tackle plastic waste, but also to reduce the production of greenhouse gases.

The discovery of a mutant plastic-eating enzyme caused a huge amount of excitement in the scientific community. But the great leap forward we are seeing now is in using Artificial Intelligence to predict what mutations would be needed to produce a whole set of "engineered enzymes" which can be used to tackle many of the sustainability issues we are facing. Amazingly, there has been about 50,000 new varieties of enzymes produced so far, and it's not just plastic which is being targeted, but it's now believed that the production of methane from food waste could be dramatically curtailed by enzyme technology. Methane has a much higher Global Warming Potential (GWP) than CO_2. Over a 20-year period, methane is ap-

proximately 84-86 times more potent than CO_2 in trapping heat in the atmosphere.

But enzymes can not only be used for plastic degradation and reduction of Greenhouse Gas emissions but can be used directly by the juice producers to reduce their environmental impact. There is a very neat and, I believe, a genuinely exciting research project which is using pomace, the byproduct of fruit juice production in the UK.

The project centres around work being done with selected enzymes from the mycorrhiza of fungi. It is being undertaken by a team at Northumbria University led by Professor Meng Zhang. The team believes it will be able to convert food byproducts into materials which will be chemically inert. For millions of years, carbon stored as oil or coal has been inert, safely hidden away from oxygen or water, but the human exploitation in the blink of an eye is causing catastrophic global climate and environmental change. Professor Zhang's team, using selected fungal enzymes has already been able to produce inert, insoluble and inoxidisable material which is hard and durable. It appears to be tough and non-flammable which is solid and sturdy enough to be used as building material, as bricks.

Fruit pomace (in this case apple or blackcurrant) is an ideal starting point for this research. It's a project which could have very long-term repercussions for the byproducts of the juice industry and is viewed as another step by a team with a vision of a genuinely sustainable future. Myself, representing the IFU SWG, have witnessed that the pomace is collected and delivered. The producer is Pixley Berries, a company which has extensive fruit farms in Southwest England and with a range of upmarket fruit juices and taking the pomace to Northumbria University in the Northeast of the country.

Blackcurrant fields in United Kingdom

Squeezing Out Solutions: Turning Environmental Challenges into Opportunities

Shannon Doherty-Andall, Sustainability Manager
Australian Beverages Council

The global fruit and vegetable juice industry, valued at billions of dollars, is at a critical juncture. Climate change, environmental stress, and natural disasters are transforming the economic landscape, causing disruptions across supply chains and creating uncertainty for juice manufacturers worldwide. From erratic crop yields to the ever-present risk of extreme weather events, the future of juice production is inextricably linked to evolving climate conditions.

Despite these hurdles, industry stakeholders have a unique opportunity to redefine sustainability in fruit and vegetable juice production. This involves not only addressing environmental concerns but also strengthening economic resilience by adapting to change in the broader supply chains that intersect with juice production. Can climate uncertainty drive a transformation in how juice is sourced, produced, and consumed? The answer lies in a forward-looking strategy that embraces appropriate localisation, circularity, and innovative value creation.

The Economics of Key Crop Flows

Understanding the economic flows of essential crops is critical. Juice production competes for key ingredients such as citrus fruit with other industries, including cosmetics, personal care, and perfumes. The economic value of citrus extends far beyond juice. Essential oils derived from these crops are pivotal in a range of consumer products, making them a vital agricultural asset with cross-industry dependencies.

For the Australian juice industry, this means taking a broader view of how environmental shifts might affect not only juice yields but also the availability of these crops for other high-value applications. As climate impacts continue to alter crop production in traditional growing regions, it's essential to understand the interconnected nature of agricultural supply chains. A resilient juice industry will require collaboration with stakeholders in related sectors to map out potential shifts in supply and demand dynamics. This knowledge can help anticipate disruptions and seize new opportunities, especially if crop yields fluctuate due to extreme weather patterns.

Future-Proofing Global Sourcing Strategies

Future planning will be fundamental to maintaining supply chain stability. One of the key questions facing the industry is: Where will the most successful growing conditions for juice crops emerge in the coming decades? As climate change reshapes agricultural viability, traditional growing regions may experience increasingly unpredictable yields or, in some cases, in the longer term may not be suitable for large-scale production. At the same time, previously unsuitable locations for cultivation could re-emerge. The UK used to grow wine grapes from 1400 to the mid-19th century; now viticulture is returning to southeast England as temperatures rise.

To balance these shifts, the industry should consider diversified sourcing strategies that include evaluating new growing regions and developing flexible sourcing models. While this approach involves greater complexity, it also opens the door for more sustainable practices, such as reduced transportation emissions by establishing more localised supply chains closer to the final production facilities. On the opposite side of the coin, rapid destabilisation of regions could necessitate rapid upskilling and industrialisation in others, with resulting repercussions on both the environment and economy.

For the Australian juice industry, rebalancing production between fresh juices and concentrates based on evolving market demands could unlock new efficiencies. Concentrates, which require less immediate processing and are more adaptable for a variety of end uses, can serve as a buffer against seasonal shortages and open up new export markets for Australian juice manufacturers. This flexibility is particularly valuable when adverse weather conditions affect the availability of fresh juice fruit.

Balancing localisation for fresh product demand and insourcing competitive supply for concentrates is one way to mitigate future climate variability. Achieving consumer pricing that makes that investment sustainable will require skilful management.

Embracing Circularity

Circularity offers another promising pathway to sustainability in juice production. Crop underperformance due to environmental stressors can lead to significant market gaps, affecting the availability of specific ingredients. However, this challenge can be turned into an opportunity by transforming crop waste into value-added products.

For instance, waste from juice processing—such as peels, pulp, and seeds—can be made into ingredients for food, cosmetics, personal care or animal feed, minimising waste and supporting local markets. This shift towards circularity enhances the economic value derived from each crop and mitigates the environmental impact by reducing additional resource extraction.

The localisation of production can also help address some supply chain risks by establishing more regionalised processing hubs. This model can be particularly relevant for Australia, where diverse climatic conditions allow for a variety of fruit and vegetable production across different states. By focusing on building more resilient, local supply chains, the industry can better withstand global disruptions and provide a stable supply of high-quality products.

A Future-Ready Industry

The path forward for Australia's fruit and vegetable juice industry lies in its ability to adapt, innovate, and collaborate. The challenges brought about by climate change and environmental degradation are indeed formidable, but they also present a unique opportunity to build a more resilient, sustainable, and economically robust sector.

By leveraging a comprehensive understanding of the economic flows of key crops, embracing localisation and circularity, and being agile enough to shift production in response to changing consumer demands, the juice industry can not only overcome these hurdles, but also thrive in a rapidly evolving global landscape.

Pasteurization of Juices and Purees without Steam

Jose Biot, Global Technical Director, Citrus Processing, Diversified Food & Health at JBT Corporation

With global environmental concerns at an all-time high, the agri-food industry is poised to make significant contributions to sustainability. In the fruit and vegetable sector, food safety is paramount, and pasteurization plays a crucial role. Historically, steam has been the primary energy source for pasteurization since the Industrial Revolution. Despite advancements to cleaner combustion methods, such as using natural gas, steam generation still represents a significant carbon footprint.

The Need for Sustainable Alternatives

There is an urgent need to develop sustainable methods for producing safe food while reducing environmental impact. An ideal solution would create a green circular process with a zero overall energy balance. Renewable energy sources, such as solar power, offer a promising path forward.

At JBT, we have successfully combined various technologies to design a machine that uses photovoltaic solar energy for pasteurization instead of steam.

JBT Stereideal™ Coil Heat Exchanger

The JBT Stereideal™ Coil system is a smart solution with a long history of application in the dairy industry. It has been extended to juices and beverages, including high viscous products, with over 50 years of trusted experience. This system offers high thermal regeneration efficiency, achieving 85% as standard and up to 93% excluding de-aeration. The coil system improves uniform heat transfer by up to 30% compared to straight tubes due to the Dean effect, which enhances mixing and heat transfer in curved pipes.

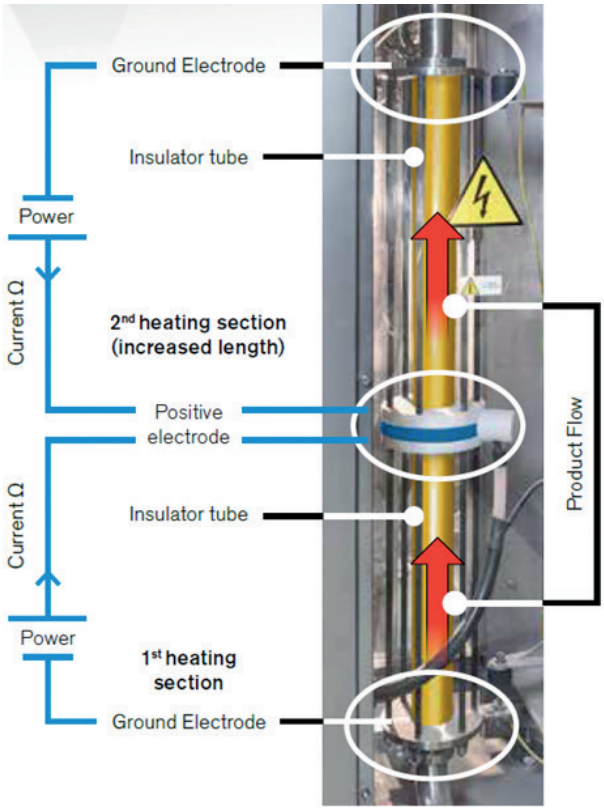
The Coil system has a small and compact footprint and eliminates the need for indirect steam-superheated water-product heat exchange, allowing for faster and more accurate temperature control. Additionally, the system

features low operating costs, with minimal parts to overhaul and reduced product losses. It ensures maximum aseptic safety due to fewer gaskets and high-pressure resistance. The system's design safeguards temperature on parallel tubes and features a fully welded product channel in the shell-and-tube heat exchanger, providing ultimate product safety and full traceability.

The system also boasts FDA approval, maintaining product fibers and particles within their dedicated tubes. This ensures minimal product damage and better product quality with gentle particle handling. The system's unique and enhanced heat transfer results in optimal product quality, making it ideal for processing at higher product pressures.

JBT Stereideal™ Ohmic Heating Technology

The JBT Stereideal™ Ohmic Heater utilizes the electrical resistance of food to generate heat quickly and efficiently. The heating speed is impressive, with a 10°C/second heating rate compared to the typical 0.5°C/second rate of conventional tube heat exchangers. This rapid heating results in shorter cooking times, preserving the organoleptic properties of food such as color, texture, and taste, while retaining nutritional value.



The product undergoes minimal structural damage, providing excellent processed quality in minimal operating time. Research indicates no protein denaturation at high temperatures when using ohmic heating. The technology volumetrically heats the entire mass of the food material, providing a homogeneous treatment and eliminating issues of overheating liquid foods containing large particles.

Additionally, it is not subject to fouling, as there is no hot wall, and does not damage particles as conventional heat exchangers do. The technology offers significant quality advantages for products with dices, liquid eggs, fruit and vegetable juices, purees, concentrates, isotonic/energy drinks, and soups and sauces with fish and meat. When combined with holding and traditional cooling, the system is ideal for aseptic treatment of high and low acid products.

The modular, compact, and flexible system ensures high energy efficiency of 92-95%, reduced maintenance costs, and extreme flexibility to process various products, including viscous and particulate ones. Although the operating costs of ohmic heating (electricity) are higher than those of conventional steam-based systems, using green renewable sources for electricity can offset this, resulting in higher product quality.

Combining Technologies for Sustainable Pasteurization

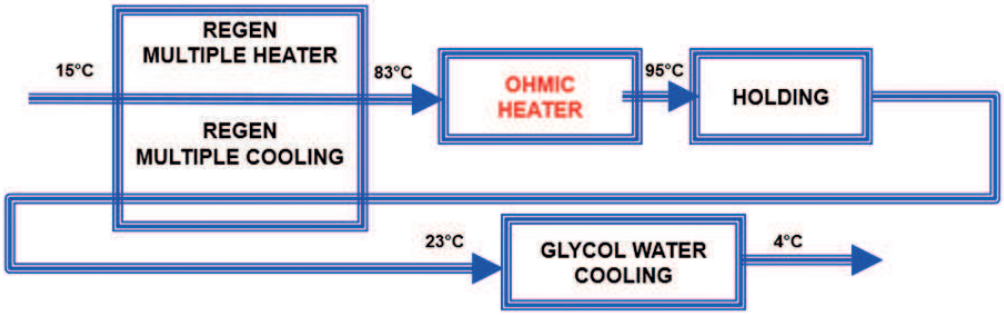
At JBT, we have integrated the JBT Stereideal™ Coil Heat Exchanger with the JBT Stereideal™ Ohmic Heating Technology to create a machine that eliminates the need for steam in pasteurizing juices and purees. This combination leverages the high thermal regeneration efficiency of the Coil and the rapid heating power of the Ohmic Heater.

In this system, the steam heater in a conventional pasteurizer is replaced by the Ohmic Heater to perform the pasteurization step, providing only 15% of the total heating energy. The preheating is achieved through multiple steps of regeneration heat exchangers in series, taking advantage of the Coil's high efficiency.

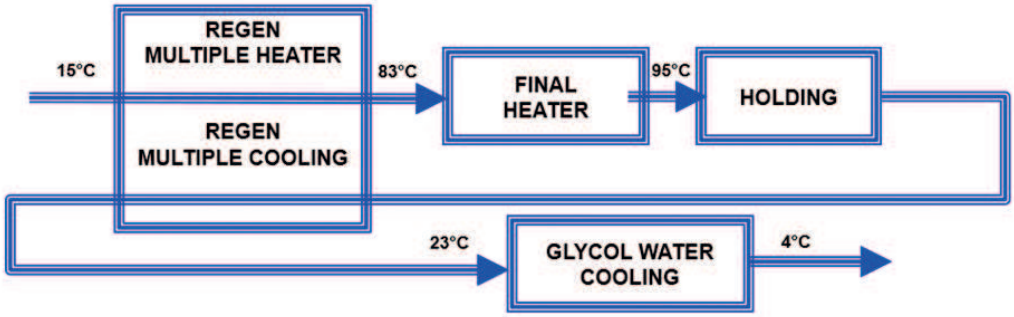
Operational Cost Comparison

A case study comparing the operational costs of Ohmic Heating versus Conventional Steam Heat Exchangers is outlined below, based on real industrial energy costs (Spain, May 2024).

Coil + Ohmic Pasteuriser
Direct Regeneration (product-product)



Coil Pasteuriser
Direct Regeneration (product-product)



For the conventional pasteurizer, with a flow rate of 12,000 kg/h of orange juice and a required heating power of 142,500 kCal/h, the steam consumption is 294 kg/h at 8 barg saturated and dry live steam, with a steam cost of EUR 36 per 1,000 kg of steam; the electric motor power requirement is 80 kW, with an electricity cost of EUR 0.038 per kWh. The running cost is EUR 14 per hour, leading to EUR 28,000 for a 2,000-hour season. The equivalent greenhouse gas emissions (CO2 footprint) per season would be 150 mT CO2.

In contrast, the Coil + Ohmic Pasteurizer, with the same flow rate and required heating power, has an ohmic efficiency of 92-95%, resulting in an electric power requirement of 174 kW, which added to the electric motor power becomes 254 kW. With electricity costing EUR 0.038 per kWh, the running cost is EUR 10 per hour, totaling EUR 20,000 for a 2,000-hour season. The equivalent greenhouse gas emissions (CO2 footprint) per season would be 212 mT CO2.

Energy costs vary by country and customer contracts with utility companies, which can affect the relative costs of Ohmic versus steam heating. However, if the Ohmic Heater uses renewable energy sources such as photovoltaic solar panels, running costs as well as CO2 footprint could be zero.

Advantages of the Zero Emission Pasteurizer

In a scenario where renewable energy sources are utilized, the advantages of this system include eliminating the use of fossil fuels, utilizing green source electrical energy, and achieving zero heating energy costs with self-produced electricity.

If the infeed temperature is higher than the output temperature, no cooling energy is required, resulting in almost zero running costs and a zero CO2 footprint. This innovative approach makes the concept of a “Zero Emission Pasteurizer” a reality, representing a significant step forward in creating sustainable food processing solutions that meet the highest standards of food safety and quality while minimizing environmental impact.

Advancing Sustainability in the Fruit Juice Industry Through Enzyme Innovation

Klaudija Milos, Business Director, AB Enzymes

Introduction

In the dynamic environment of the fruit juice industry, sustainability remains a critical objective for companies striving to reduce their environmental impact while enhancing production efficiency. The role of enzymes in achieving these sustainability goals is particularly significant. As natural catalysts, enzymes provide a range of benefits, from reducing energy consumption to minimizing resource waste.

The Distinct Mechanism of Alpha-Amylase in Apple Juice Concentrate Production

Apple juice concentrate (AJC) is a widely consumed product, necessitating precise processing to ensure high quality and consistency. A recurring challenge in this process is the management of starch, which, if inadequately degraded, can lead to complications in subsequent processing stages. Unlike the commonly employed glucoamylases, which primarily convert starch into glucose, alpha-amylase operates through a different mechanism. This enzyme degrades starch into shorter sugar molecules, including maltose, which has notable implications for the production process.

Sustainability Benefits: A Case Study

To illustrate the impact of an alpha-amylase, consider a standard apple juice facility where the commercial product ROHALASE® AFL has been integrated into the production process. Traditionally, starch degradation is necessary to prevent cloudiness in the juice concentrate, which can pose challenges during filtration.

The introduction of ROHALASE® AFL has significantly improved the filtration process, leading to several sustainability benefits:

- Reduction of Filtration Sheets Required: The enhanced degradation of starch results in less residue during filtration, thereby reducing the need for filtration sheets. With ROHALASE® AFL, 5-6 times fewer filter sheets are used. The reduced filtration needs not only diminish material waste but also decrease the frequency of filtration sheet replacements, saving both time and labor costs.

- Reducing Losses and Increasing Yields: With every filter sheet used, some juice is usually lost. To reduce these losses, the filters are washed to recover juice, and reprocessing starts. Reducing filtration to a minimum is the ultimate target in operations.

- Energy and Resource Savings: The increased efficiency of the filtration process reduces the energy required to achieve the desired clarity in the juice concentrate and avoids reprocessing, altogether contributing to a more sustainable production cycle.

All this also comes with a significant economic impact. In this case study of a typical apple juice production facility, manufacturing approximately 10,000 tons of AJC per year, the integration of ROHALASE® AFL into the starch degradation process has led to annual savings of €117,000. These savings are derived from reduced material costs, reduced labor costs, and reduced losses and waste. The lower energy consumption has not yet been included in the calculations.

The Need for Legislative Adaptation

As the fruit juice industry increasingly adopts advanced technologies such as alpha-amylase, it is crucial for regulatory frameworks to evolve in tandem. The presence of maltose in juice products, for example, should not be immediately construed as an indication of food fraud. Instead, it should be understood as a natural consequence of employing more efficient enzymes in the production process. To support the industry's progression toward sustainability, legislation must remain flexible and responsive, acknowledging the benefits of new technologies rather than penalizing their outcomes.

Embracing New Technologies: The Case for Cellulases

However, the discussion surrounding enzyme use extends beyond alpha-amylase. Consider the case of cellulases, enzymes that are capable of breaking down cellulose, a primary component of plant cell walls. While these enzymes can significantly enhance juice yields by degrading the fibrous parts of fruits, their use is not permitted globally. European manufacturers and regulators have shown reluctance to embrace cellulases, citing a perceived lack of necessity. However, this hesitation results in considerable amounts of valuable product being left as waste.

In an era where sustainability is paramount, it is increasingly necessary to reevaluate traditional manufacturing practices and to be open to new tools and methods. By incorporating enzymes such as cellulases into the production process, the industry could substantially reduce waste and ensure that more valuable material is introduced into the global food chain. This approach would not only improve the efficiency and sustainability of juice production but would also align with broader environmental objectives.

A Future of Fiber: The Next Frontier in Enzyme Innovation

As the industry looks to the future, another groundbreaking application of enzymes is on the horizon—one that has the potential to further impact fruit juice production. Consider the possibility of converting sugars naturally present in juice into valuable dietary fibers, thereby enhancing the nutritional profile of the juice.

This concept is not merely speculative; it is a near-term reality. Enzymes designed to convert sugars into fibers could transform juice into a healthier, more sustainable product by retaining more of the fruit's natural nutrients. However, as with cellulases, regulatory barriers continue to impede progress. Despite the clear advantages of this technology, regulatory bodies have been slow to recognize and approve these new methods. This reluctance hinders the industry's advancement, potentially delaying the implementation of sustainable practices that could benefit both producers and consumers alike.

A Call for Openness

As the fruit juice industry stands at the intersection of tradition and innovation, the path forward is evident: it involves embracing new technologies, reassessing outdated assumptions, and advocating for regulatory frameworks that support progress. The examples of enzymes such as alpha-amylase, cellulases, and those designed to convert sugars into fibers demonstrate the transformative potential of innovation. These enzymes are not merely altering the production process; they are redefining what is possible in terms of sustainability and efficiency.

While the will to progress is crucial, it must be accompanied by decisive action. The time to embrace these innovative technologies is now. The industry must move beyond outdated practices and advocate for the necessary regulatory changes that will enable sustainable growth. We must not passively await the future; rather, we must actively shape it by adopting these advancements today, thereby ensuring a healthier, more sustainable world for future generations.

Case Study Apple Juice Concentrate (AJC)Production: Total plant capacity 10.000t p.a Performed in Europe in 2023

	ROHALASE® AFL	Glucoamylase
Total AJC manufactured [t] in trial period	780	946
Filter sheet spent [pieces]	396	2772
Labour at sheet replacement in h	4.5	31.5
Filtration loss in €/t AJC	2.16	12.44
Total Economic impact in €/10.000 t AJC when using ROHALASE ® AFL	117,412	

Sustainable Juice Platform

Athanasios Mandis, Chair of the Sustainable Juice Platform

It's been a productive year since our first feature in the IFU Sustainability Report 2023. Last year, we introduced the Platform's role and objectives. This year, we'll focus on our work in the citrus sector, including the recently concluded co-funded study on the ecosystem services provided by beneficial insects in Brazil's citrus belt. Our findings confirmed that orange groves farther from conservation areas in the Mata Atlântica and Cerrado biomes had reduced presence and richness of beneficial species. Interestingly, alternative land use had a greater impact on pest pressure than the conservation areas, with groves near sugarcane and grasslands experiencing fewer pests. We are collaborating with Brazilian partners to further investigate this link. We also organised a citrus visit in Valencia, Spain, where Platform members, Spanish academics, and research institutes explored the Innocent Drinks beacon project. The project demonstrated the benefits of grass and wildflower enhancement in orange groves, promoting thriving pollinators and natural enemies. At the IVIA Research Station, we saw how flowering species are being used to improve productivity and benefit insect populations.

The field visits underscored how vegetative enhancement can boost citrus productivity and climate resilience by limiting the spread of the citrus psyllid, the vector for huanglongbing (LHB) bacterial disease, commonly known as greening. We look forward to continue exploring this promising frontier with our partners in Spain and Brazil.

50 years of Expocitros

In anticipation of the 50th anniversary of Expocitros (2025), Brazil's premier citriculture event, we're collaborating with key Brazilian stakeholders to organise a series of meetings, workshops, and events. Our goal is to highlight the sector's impressive sustainability efforts while aligning with new European regulatory requirements. It's also a chance for us to expand the Platform's reach and strengthen its role within Brazil's citriculture industry. Please get in touch if you are interested in getting involved.

Fig 1. Example of wildflower strip introduced in citrus production

New website!

We'll be promoting the Brazilian citriculture sector and other work through our website and social media. This presents a great opportunity for us to showcase our newly revamped site at https://sustainablejuiceplatform.eu/. Here, you can find more about the Platform and updates on our work. We encourage juice value chain actors to get involved and help shape the sustainability agenda. While our roots are European, we warmly welcome members from across the global juice industry!

Fig 2. IVIA research plot into the spatiotemporal performance of different wildflower species.

Advancing Circular Policies in Agrifood Systems – FAO's Perspective

Tatiana Campos, IFU Executive Director

In September 2024, an article by FAO authors titled "Opportunities and Challenges for Global Food Safety in Advancing Circular Policies and Practices in Agrifood Systems" was published in Nature. This article was prepared to address the growing need for sustainable agrifood systems as global challenges such as population growth, resource depletion, and climate change intensify. The transition from linear to circular practices, aimed at improving sustainability, brings with it significant food safety concerns, which the authors seek to explore and address.

The article, authored by Andrew J. Pearson, Keya Mukherjee, Vittorio Fattori, and Markus Lipp, focuses on three critical areas where circular practices influence food safety: water reuse, food loss and waste (FLW) valorization, and packaging waste recycling. Each area presents unique risks. For example, water reuse in food production could introduce pathogens, pharmaceuticals, or antimicrobial-resistant organisms, while FLW processing might carry harmful contaminants that could re-enter the food chain. The reuse and recycling of packaging materials also introduce potential contamination risks if not properly managed.

One of the central challenges highlighted in the article is the need for more detailed research to fully understand the food safety risks associated with circular systems. Current food safety regulations are largely designed for linear processes, and circular models bring new types of hazards that require new risk assessments. The authors emphasize that developing and adapting robust safety frameworks is crucial to mitigate these risks and ensure that circular agrifood systems are safe.

Additionally, the article identifies opportunities for improving food safety in circular systems. For instance, advancements in water treatment, safer packaging materials, and better management of food waste can contribute to reducing the risks associated with contamination. Circular practices also offer a chance to phase out contaminants that persist in linear systems and promote safer food products.

Table 1: Summary of reviewed themes and initiatives for advancing circular practices and policies in the agrifood system with overview of risks and benefits to food safety

Theme	Water re-use	Food loss and waste	Packaging waste
Problem summary	Limited clean freshwater resources. Inefficiency of water use. Increasing water stress.	High avoidable food los and waste at production, retail and household levels. Poor utilisation of food by-product waste.	Finite virgin resources. Design for singe use. High waste generation.
Initiatives considered in the review	Reuse in-system or in closed loops. Recycling alternative water sources.	Valorisation and conversion. Nutrient or energy recovery. Consumer Education.	Reuse. Recycling materials. Redesign to reduce waste.
Risks to Food safety	Persistence of pathogens, parasites and chemical contaminants. Anti-microbial resistance.	Persistence of pathogens, parasites and chemical contaminants. Anti-microbial resistance. Micro and nano-plastics. Compromised food handling.	Transfer of pathogens or contaminants from prior uses. Migration of non-intentionally added substances. Loss of integrity.
Benetis to food safety	Phase out of segregation of persistent contaminants. Increased treatment efficacy.	Use of materials with reduced risk profiles. Phase out or segregation of persistent contaminants. Increased treatment efficacy. Improved education on household food safety.	Use of materials with reduced risk profiles. Improved integrity of packaging

From: Opportunities and challenges for global food safety in advancing circular policies and practices in agrifood systems

In conclusion, the article underscores the need for strong food safety measures as agrifood systems shift toward circular models. This emphasis on safety extends to industries like juice production, where circular practices, such as by-product valorization and zero-waste initiatives, are gaining traction.

The International Fruit and Vegetable Juice Association (IFU) plays a pivotal role by providing updated methods and guidelines that ensure safety throughout these processes. Key examples include MM2 (Total Count of Potential Spoilage Microorganisms), MM6 (Spore Count of Mesophilic and Thermoduric Bacteria), and MM12 (Detection of Thermo-Acidophilic Spoilage Bacteria) and the recently released MR2 (Heat treatment calculations for fruit juices and beverages) and MR3 (Reference strains for IFU microbiological methods). Moreover, BPG #4.0 (By-product Valorisation Thermal) offers comprehensive guidance on converting fruit processing waste into energy, helping juice producers balance sustainability with safety.

By ensuring that food safety standards evolve alongside circular economy practices, the juice industry and IFU are helping to minimize risks, maintain consumer trust, and contribute to global sustainability goals. This alignment between safety and sustainability is critical for the future of the agrifood sector, particularly as the industry adapts to new models that prioritize efficiency, waste reduction, and environmental stewardship.

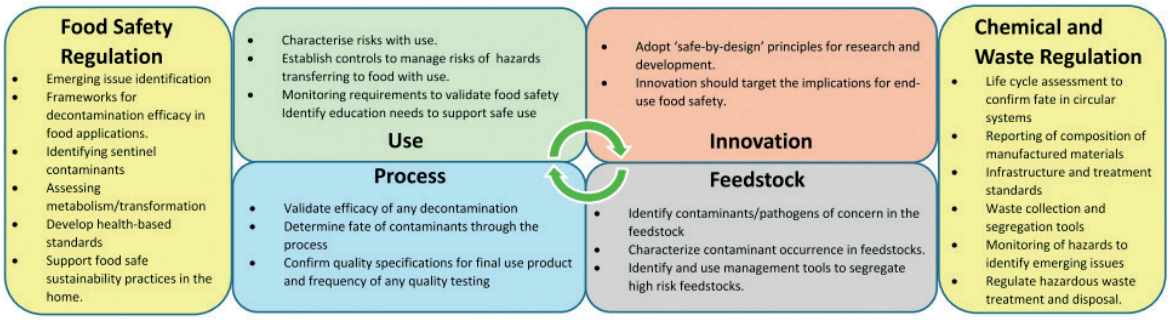


Fig 1: Focus points for food safety in transforming to circular practices and policies in agrifood systems.

References:

1. Pearson, A. J., Mukherjee, K., Fattori, V., & Lipp, M. (2024). Opportunities and challenges for global food safety in advancing circular policies and practices in agrifood systems. npj Science of Food. https://doi.org/10.1038/s41538-024-00286-7

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