Policy Brief

FOX – Food processing in a Box

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 817683.

Introduction

Europe's agricultural sector is a leading global food producer, ensuring food security for over 500 million citizens. Within the European Union (EU), the food and drink industry stands as the largest manufacturing sector. The majority (>90%) of both sectors are comprised of micro and small-sized companies. However, due to global food chain consolidation, rising labor costs, and a focus on scale in food processing, value-addition has shifted downward. Unfair practices in the food chain worsen this trend, disadvantaging farmers and small food producers. Conversely, consumer preferences for healthier, local, and traditional food drive the need for innovations in processing, product development, and distribution.

The FOX project has successfully developed innovative, flexible technologies tailored for the fruit and vegetable sector in Europe. It specifically caters to small and medium-sized companies and farmers, offering mobile and flexible processing units equipped with advanced technology. This project emphasizes mild processing techniques ranging from preservation to packaging and rapid quality control, aiming to enhance healthier food production. Implemented across major EU regions known for their fruit and vegetable production, the project has effectively evaluated new business opportunities. It has also assessed its environmental, social, business, and health impacts. Furthermore, the project's outcomes are being actively promoted by a European Interest Group of small-scale food processors, marking a significant step forward in the industry.

Fruit and vegetable products, along with their side streams, are central to the evolving landscape of modern culinary culture, offering a diverse palette of flavors, textures, and health benefits. This includes not only fruit juices and purees but also fresh food products that are integral to a balanced diet. The global demand for these natural, nutritious, and high-quality offerings continues to rise, driven by consumer preferences. The FOX project specifically focuses on these products due to their significant potential in promoting sustainable food systems and reducing waste. However, the traditional methods of processing these products – encompassing juice extraction, drying, packaging, and preservation – present several challenges. Addressing these challenges is crucial for maintaining the integrity and quality of the products while meeting the growing consumer demand.

The existing policy landscape concerning sustainable and healthy food consumption is marked by substantial fragmentation. Since its inception, European institutions have consistently prioritized ensuring food availability at equitable prices as a key objective. This commitment is explicitly outlined in the Treaty of Rome and remains a fundamental goal of the Common Agricultural Policy (CAP), established in 1962. Although the CAP has undergone numerous reforms over the years, it remains the primary EU policy governing the food sector, exerting a substantial influence on the sustainability of agricultural production. The CAP predominantly revolves around the

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interests of farmers and relies heavily on direct payments to provide them with a stable income in the face of volatile market prices and demand. This farmer-centric approach has faced criticism for preventing the CAP from evolving into a comprehensive framework encompassing the entire European food system (Galli et al., 2020).

The European Commission's 2020 Farm to Fork strategy aims to holistically govern EU food systems. While it assumes consumers make informed food choices, studies show choices are influenced by habits, emotions, and the food environment. Access to sustainable products is limited if not readily available in stores, and consumers need trusted information to gauge a product's environmental and social impact. A shift in consumer attitudes and behaviors could certainly play a significant role in making the entire food system more sustainable. However, the policy interventions should not solely focus on consumers but should also encompass food providers, producers, manufacturers, distributors, and retailers.

This policy brief will provide an examination of FOX innovative methods, drawing from recent research, practical applications, and expert insights. It aims to equip policymakers, industry leaders, and stakeholders with the knowledge and recommendations needed to foster a more sustainable and resilient food processing sector.

The subsequent sections will delve into findings, focusing on specific technologies, applications, benefits, challenges, and policy implications, setting the stage for informed decision-making and strategic action.

Challenges of the food system

Environmental impact

Energy-intensive methods, excessive water usage, waste generation, and disposal contribute significantly to the environmental burden of the food system. From greenhouse gas emissions to the handling of food side streams, the ecological implications are extensive and complex. Approximately 10% of the EU's greenhouse gas (GHG) emissions originate from the agri-food industry, with close to 70% associated with livestock farming, not accounting for the effects of imported foods. Livestock in Europe is responsible for 53% of the EU's overall human-caused methane emissions.

Furthermore, our agricultural and economic policies, geared towards maximizing efficiency and yield, have significant consequences for waste generation. Today's agricultural production, trade, and distribution processes often result in the creation of by-products and surpluses. For economic reasons, these materials are frequently discarded. In the best cases, they are redirected towards biogas plants for energy production, contributing to a circular economy approach. However, this does not mitigate the fact that a considerable amount of potential food resources are wasted.

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This waste issue not only reflects inefficiencies in our food systems but also represents a lost opportunity to reduce environmental impacts and improve sustainability in food production and distribution.

World population

Over the span of 63 years, from 1959 to 2022, the global population witnessed a staggering growth, nearly tripling from 3 billion to 8 billion. This surge in population presents both challenges and opportunities in terms of sustainability, resource management, and social infrastructure. Current estimates project that this upward trajectory will continue. By 2030, just 8 years from 2022, the global population is expected to reach 8.5 billion and further ascend to an astounding 9.5 billion by the mid-century mark in 2050 (United Nations, 2022). As we navigate the future, it's crucial to address the implications of such rapid growth and develop strategies to ensure a balanced coexistence on our planet.

Food insecurity

The onset of the Covid-19 pandemic brought about unprecedented challenges to global food systems, exacerbating an already critical situation for many regions. By the end of 2021, food insecurity had surged to affect approximately 2.3 billion people worldwide, constituting 29% of the global population. This was a stark increase of 350 million individuals compared to the period before the pandemic outbreak (FAO, 2022). The impact of conflicts on food security is yet to be determined.

Economic considerations

Rising energy costs, waste management expenses, and the potential loss of valuable by-products strain economic sustainability. Small and medium-sized enterprises (SMEs) may find it particularly challenging to adapt to these costs.

Consumer expectations and acceptance

Consumer expectations globally are evolving, showing a marked trend towards transparency, ethical sourcing, and sustainable production in our food systems. This shift transcends socio-economic boundaries and is not limited to any specific demographic. Addressing these expectations necessitates a transformative approach in food processing techniques and practices, one that resonates with people from varied backgrounds.

Embracing upcycled plant side stream products, for example, presents a unique challenge. While these products offer a sustainable alternative, appealing to consumers across different regions can be complex. Hesitancy often stems from unfamiliarity with new products or those made from unconventional ingredients, despite their safety and nutritional benefits. Overcoming this barrier is critical, requiring

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concerted efforts in building trust and educating consumers about the benefits of such products, irrespective of their socio-economic status.

Competition with conventional products

Upcycled plant-side stream products often face competition with traditional products that consumers are already familiar with. Convincing consumers to choose upcycled options over established products can be a hurdle.

Quality and consistency

Conventional techniques, such as heat treatment and high oxygen exposure during juice extraction and preservation, result in nutritional loss, flavor alteration, and shelf-life reduction.
On the other hand, maintaining the quality and consistency of upcycled products can be challenging, especially when dealing with variable plant side streams.
Ensuring that these products meet consumer expectations is essential for success.

Regulatory Compliance

Evolving regulations and standards related to food safety, quality, and sustainability necessitate continuous adaptation and compliance, adding complexity to the production process.

Recognizing these challenges, the industry is actively exploring and adopting alternative technologies and practices. Innovations such as low-oxygen juice extraction, mild preservation using Pulsed Electric Field (PEF), sustainable low-temperature drying technologies, and upcycling of plant-based food side streams present opportunities to revolutionize food processing. These innovations not only address the aforementioned challenges but also open doors to new product possibilities, enhanced consumer satisfaction, and alignment with global sustainability and circular economy principles.

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The benefits of the FOX project

A fundamental shift in our approach to food processing and consumption, particularly in Europe, is necessary. The FOX project introduces several innovative techniques, from low-oxygen juice extraction and gentle preservation that maintains the fresh taste and nutritional value of fruit juices, to sustainable low-temperature drying technologies that enhance the quality of dried fruits, vegetables, and mushrooms. Furthermore, the significance of sustainable packaging for fresh snacks and the upcycling of by-products from plant-based foods cannot be overstated. Our mobile units, equipped with innovative technology, enable on-site processing of fruits and vegetables. This not only reduces transportation costs but also ensures freshness and nutritional value are retained. The flexibility of these units allows for operation in various locations, catering to the needs of small-scale farmers and producers in diverse environments.

Emphasizing a local approach, the FOX project aims to empower regional food systems. By focusing on local production and processing, we contribute to the sustainability and resilience of local economies. This approach supports small-scale producers by providing them with the tools and technologies to process their produce effectively and efficiently, fostering community engagement, and enhancing local food security.

The promotion of FOX innovations can play an important role in addressing the complex challenges within the EU food system.

Low oxygen juice extraction and mild preservation

A small-scale, mobile, and flexible fruit processing unit has been developed by integrating scaled-down technologies to ensure ease of use across various locations, raw materials, and final product specifications. The FOX mobile unit is specifically designed for extracting fruit juices and purees in an oxygen-reduced environment. This innovative extraction system is coupled to a gentle preservation - Pulsed Electric Field (PEF), ensuring improved quality while offering maximum flexibility for a wide range of applications.

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Figure 1. Illustration of the different phases of juice production within the FOX project.

Figure 2. Example of some of the fruit juices obtained from the FOX mobile container.

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Sustainable, low-temperature drying technologies for soft fruits, vegetables, mushrooms, and their derivatives

A mobile and flexible drying unit has been developed integrating non-thermal pre-treatment techniques with conventional and unconventional drying systems. This innovation enhances process kinetics and improves the quality of dried plant material, enabling the utilization of unstable plant-origin materials. The drying unit enables pilot-scale production and can operate both with and without the application of PEF pre-treatment. This versatility allows for flexible utilization, depending on the user's specific requirements and capabilities.

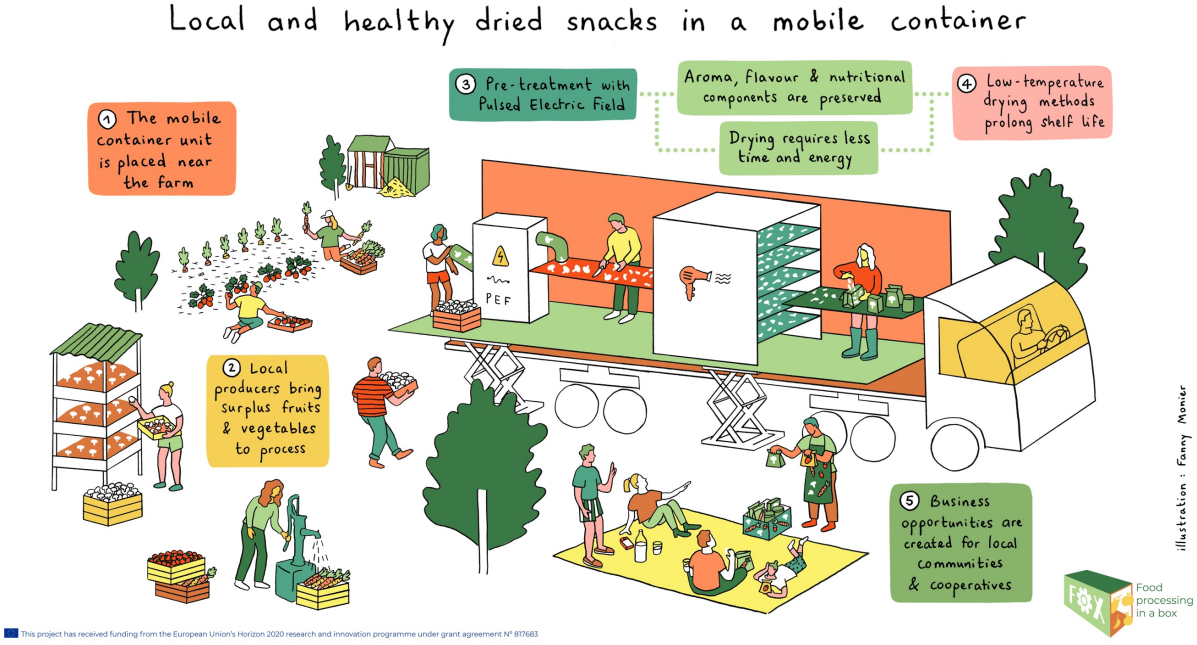

Figure 3. Illustration of the different phases of fruit and vegetable snacks production within the FOX project.

Innovative quality analyses and sustainable packaging for fresh fruit and vegetable snacks

A sustainable packaging system for fresh fruits and vegetables snacks was developed within FOX project. The system adapts to the quality of raw materials, using minimal processing and small-scale packaging units. The secondary packaging is made of a new biocomposite with recycled cork. The quality of fresh fruits and vegetables and new sustainable packaging systems (primary and secondary) for the preservation and distribution of fresh fruit and vegetable snacks that are produced are analyzed and packed in small-scale and mobile units.

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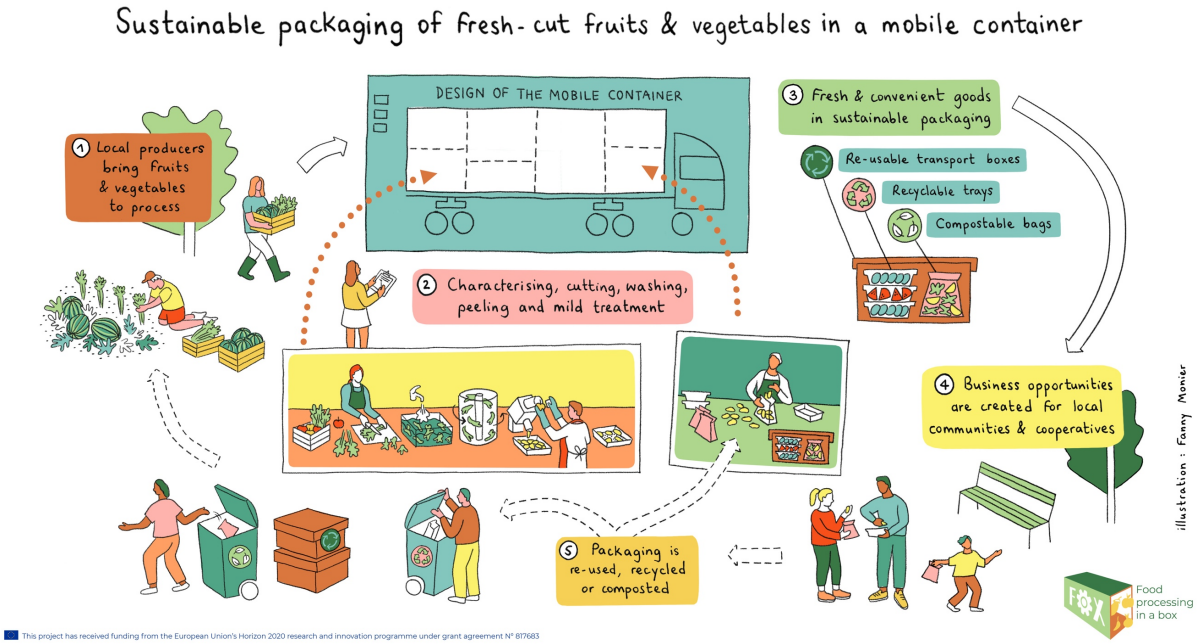

Figure 4. Illustration of the different phases of sustainable food packaging production within the FOX project.

Upcycling of plant-based food side streams using mild processing

Mild processing methods and research on upcycling plant-based side streams aim to preserve natural ingredients, produce high-quality products, and reduce food waste. Understanding upcycling is essential for companies making decisions about food loss and waste. The *Processtimator* software tool developed within FOX project assists in designing and analyzing upcycling pathways, considering various factors influencing costs and material properties. This includes estimating costs, examining material properties, and considering the impact of processing choices, material variations, and uncertainties.

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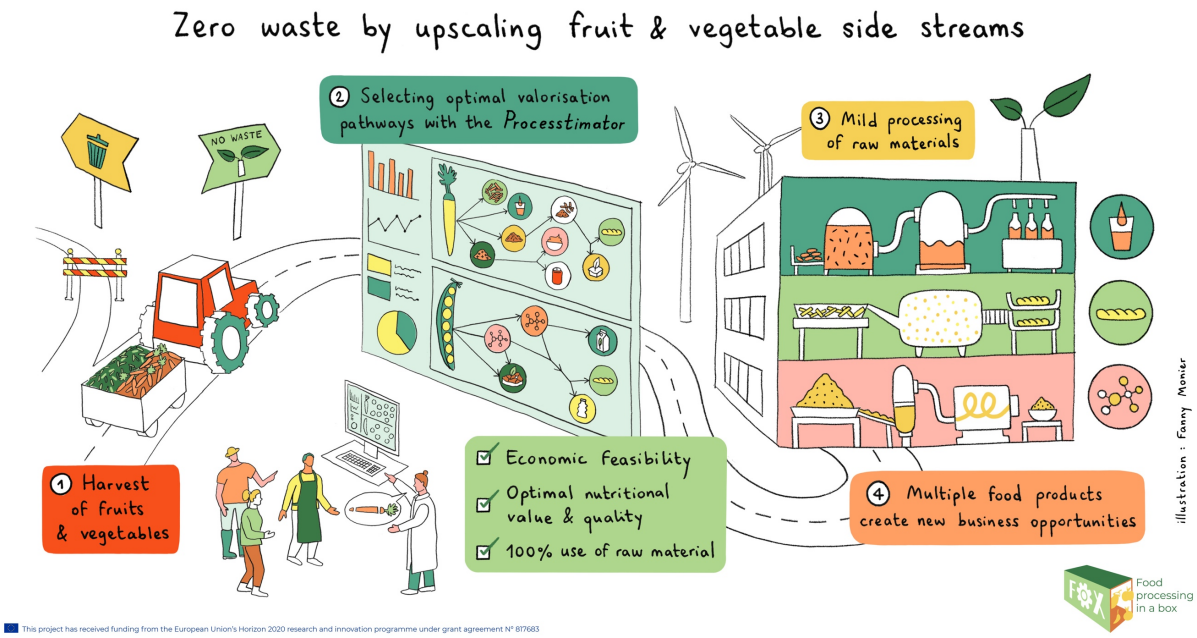

Figure 5. Illustration of the different phases of the upscaling of fruits and vegetables side streams.

Policy recommendations

The approaches of FOX project lay the groundwork for a food system that prioritizes sustainability, resilience, and health. By incorporating local value chains, these methods enhance community engagement and support local economies, ensuring that the benefits of sustainable practices are felt more directly and immediately by those involved. With their decreased carbon footprint, reduced resource use, and minimized environmental impact, these changes are in line with the recommendations of the Intergovernmental Panel on Climate Change (IPCC) for enhancing climate resilience.

To accelerate the development and scaling of sustainable products and technologies in the EU, a more constructive, holistic, and encouraging policy framework is paramount. By leveraging existing policy and regulatory tools, we can foster an enhanced environment for the growth of sustainable products and technologies and, more broadly, advocate the transition towards a sustainable, resilient, and nutritious food system.

Foster innovation clusters or technology hubs

Encourage the formation of innovation clusters or technology hubs where businesses, researchers, and government entities come together to support and advance specific areas of innovation along the agri-food value chain such as the FOX project innovations in the food industry. These clusters facilitate knowledge sharing, resource access, and cross-sector partnerships to drive technological advancements, economic growth, and sustainability within a particular domain. They often include shared

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facilities, networking opportunities, and funding access to stimulate innovation and competitiveness.

Financial incentives for FOX mobile units

The flexibility and adaptability of FOX mobile units make them highly effective in meeting specific regional needs and in directly engaging small businesses and communities with innovative processing techniques.

While these units foster sustainability by minimizing transport and processing times, they also present challenges. The costs associated with their deployment, including manufacturing, maintenance, and operation, are significant. Additionally, logistical challenges in transporting these units to remote or inaccessible areas may limit their reach. Effective utilization also requires seamless integration with existing local infrastructure and supply chains.

Despite these challenges, the use of mobile processing units stands as a promising approach to enhance regional innovation, support small-scale producers, and promote sustainable food processing practices. To maximize their benefits, policymakers should consider supportive measures like financial incentives and infrastructure development to address the associated costs and logistical limitations.

Establish funding and support programs

Establishing funding and support programs entails the implementation of government-led initiatives aimed at allocating financial resources, incentives, and assistance to foster the adoption and development of innovative technologies and solutions for the agri-food chain, particularly those arising from projects like FOX. These programs aim to lower financial barriers, encourage research and innovation, and drive economic growth by providing financial support, grants, subsidies, or tax incentives to businesses and individuals engaged in projects aligned with the FOX innovations. They play a pivotal role in advancing technological progress and addressing societal challenges.

In addition to technical support for implementing sustainable practices, it is essential for stakeholders to receive government-led training and guidance on how to effectively secure funding. Offering multifaceted training programs designed to enable farmers, as well as medium-sized processors or cooperative initiatives, to understand relevant regulations and gain access to financial incentives will greatly encourage the adoption of sustainable practices. Although direct payments are straightforward for farmers, stakeholders emphasized the need for increased visibility of alternative financial support mechanisms for sustainable practices and to widen the scope of users to the whole food system and not just ro agricultural production. Policy stakeholders specifically highlighted the importance of enhancing communication about financial incentives beyond just direct payments to boost the adoption of these sustainable methods.

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Support research and development in innovative technologies

Use EU public funding mechanisms to accelerate the shift towards sustainable food systems.

Encouraging research and development (R&D) collaborations involves actively promoting partnerships and cooperative efforts between various stakeholders, including businesses, research institutions, and universities, to collectively advance scientific knowledge, innovation, and technology development. One effective approach is through the establishment and support of living labs and hubs, which act as incubators for new ideas and technologies.

Living labs, also known as innovation hubs, serve as real-life pilot sites where researchers, entrepreneurs, and end-users collaboratively explore new technologies and approaches in a controlled yet authentic environment. This participatory approach brings together diverse stakeholders, including farmers, small food producers, scientists, and policymakers, to co-create and trial innovative solutions in real-world settings.

This strategy includes establishing dedicated grants, research centers, and public-private partnerships to facilitate innovation. This approach fosters synergy, shared resources, and expertise exchange, facilitating the accelerated progress and successful implementation of initiatives like the FOX project innovations. By incentivizing and supporting R&D collaborations, policymakers aim to boost innovation, drive economic growth, and address complex challenges more effectively.

Promote sustainable practices and circular economy

Promoting environmental sustainability and incentivizing sustainability involves a multi-faceted approach:

Eco-friendly packaging

Encourage the use of biodegradable or recyclable packaging by providing subsidies or tax incentives to businesses. This reduces waste and encourages sustainable packaging choices.

Energy efficiency

Foster energy-saving technologies in processes like drying and preservation through grants and favorable financing options. This promotes efficient resource use and reduces the carbon footprint.

Encourage Upcycling

Promote the upcycling of food side streams with a focus on:

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- **Regulatory Framework.** Develop clear regulations and guidelines to ensure the safe and responsible utilization of food side streams, enhancing sustainability and reducing waste.
- **Introduce an EU-wide definition of "Upcycling".** This concept play a crucial role in promoting sustainability and resource efficiency within the food industry. However, the current lack of precise and uniform definitions may hinder effective policy development and implementation. A clearer definition is necessary to distinguish it from other waste reduction methods, such as recycling and repurposing. Providing a precise definition for upcycling will help stakeholders understand its scope and implications.
- **Introduce an EU-wide definition of "food side streams".** Food side streams, also referred to as food by-products or co-products, represent an essential resource within the food industry, but the current definition leaves room for interpretation. A more comprehensive and precise definition is essential to encompass the various materials generated during food production, processing, or consumption that are not the primary intended product. Such a definition would promote responsible resource management and waste reduction.
- **Market development:** Support market access and consumer acceptance of upcycled products through labeling, certification, and promotion, creating economic incentives for businesses to engage in upcycling. Provide financial incentives, tax breaks, or subsidies to food processing businesses that adopt innovations in their operations. This will motivate companies to invest in the latest technologies and processes. Encourage food processors to attain sustainability certifications by integrating innovations into their production processes. Certifications can be linked to benefits such as reduced environmental impact and improved product quality.

Revising the EU's agriculture promotion policy

The EU's agriculture promotion programme needs a revision to broaden the range of products eligible for the promotion. As stipulated in Article 5 of Regulation 1114/2013, this should encompass sustainable and healthy food innovations, such as those emerging from the FOX project. Under the existing Common Agricultural Policy (CAP), it's essential to incorporate agri-environmental measures within national rural development programmes. This integration would support farmers aiming to diversify their activities towards sustainable production. Moreover, for those aspiring to transition to more sustainable methods, specific measures should be set in place to assist this shift, especially in the CAP post-2027.

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Local Food at the EU level

Introduce an EU-wide definition of local food

Local food refers to food products that are produced, processed, and consumed within a specific geographic proximity (e.g. typically within a radius of 50 km). This proximity ensures a shorter supply chain, resulting in fewer emissions from transport, better traceability, and a more direct connection between producers and consumers. By prioritizing local resources and markets, local food systems support the regional economy, promote sustainability, and often reflect the cultural and culinary heritage of the area.

Establish EU-wide Sustainable Dietary Guidelines

Establish EU-wide Sustainable Dietary Guidelines that prioritize the sourcing of local food based on its benefits in terms of quality, safety, and sustainability.

National dietary guidelines currently advocate for healthy diets, but many do not align with sustainability objectives, such as those outlined in the Paris Climate Agreement. By incorporating sustainability criteria and updating the guidelines based on the most recent insights on healthy eating, we could potentially steer consumer demand towards healthier and more sustainable products. Establishing an EU-wide framework for 'best practices' in revising national dietary guidelines to bridge health and sustainability could grant everyone access to actionable information to enhance their diets.

Integration of dietary guidelines in public procurement of local food

These guidelines should be integrated into procurement practices and be supported by a comprehensive set of quality criteria, ensuring that local food procurement does not compromise food safety and standards. This approach will promote healthier and more sustainable diets for European citizens (Nunez Ferrer, 2020).

Support more collaboration among local farmers

Encourage Member States to allocate a dedicated portion of the agricultural budget to farmer-driven knowledge exchange programs. This involves sponsoring and organizing events, workshops, and seminars that focus on local farmer-to-farmer interactions, ensuring they are widely accessible. A recognition system should be put in place to identify and reward farmers actively engaged in knowledge-sharing and the practical implementation of sustainable methods. Moreover, the creation of both digital and physical platforms for farmers to collaborate, share experiences, and access resources is essential. This approach should be complemented by the active involvement of farming associations, agricultural experts, and relevant government agencies, ensuring the policy's comprehensive effectiveness and relevance. Through fostering a collaborative and knowledge-sharing culture, the widespread adoption of sustainable practices across the agricultural sector can be accelerated.

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Educate and engage consumers

Local food chains and their impact on consumer education and sustainability

Short food supply chains often have few or no intermediaries, bridging a minimal geographical gap between farmers and consumers. While local food production may constitute only a minor portion of overall consumption and, in some cases, have a larger environmental footprint than distant options, it amplifies consumer awareness of local farming practices and food quality, offering significant educational benefits. Exploring diverse avenues beyond traditional market systems enhances resilience, fosters direct connections with food and its producers, and promotes sustainable and healthy eating habits.

Implementing multimedia campaigns to educate consumers about the importance of sustainability and quality in food production is essential. This empowers consumers to make informed choices that align with environmental sustainability goals.

Consumer awareness

Public marketing initiatives, product labeling, and scoring systems on food packaging, along with advertisements and personalized digital feedback tools, play a vital role in educating individuals about healthy and sustainable food choices. These endeavors should encompass campaigns and educational programs aimed at preventing food waste. This can be achieved by minimizing overconsumption and enhancing methods related to food preparation, storage, planning, shopping, and reuse or recycling.
Policymakers should engage in dialogue with consumers, farmers, processors, and retailers to promote a shift away from unsustainable and unhealthy food products. This collaboration aims to ensure that no group faces adverse effects from these changes. The foundation of this dialogue should be the robust scientific evidence that emphasizes the need to significantly reduce the consumption of unsustainable and frequently unhealthy foods.

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FOX Project

The fruit and vegetable sector in Europe needs innovative and flexible technologies for processing. The EU-funded FOX project focuses on mobile and flexible processing units of small and medium-sized companies and farmers that offer advanced technology applications. The project concentrates on mild processing technologies: from preservation to packaging and quick quality control for healthier food production. It will be deployed in six EU regions with considerable fruit and vegetable production and will evaluate new business opportunities. In addition, it will estimate its environmental, social, business, and health impacts. The promotion of the project's method, as well as the debate concerning policy recommendations, will be promoted by a European Interest Group of small-scale food processors.

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References

Galli, F., Prosperi, P., Favilli, E., D'Amico, S., Bartolini, F., & Brunori, G. (2020). How can policy processes remove barriers to sustainable food systems in Europe? Contributing to a policy framework for agri-food transitions. Food policy, 96, 101871.

FAO, IFAD, UNICEF, WFP, WHO, The State of Food Security and Nutrition in the World 2022. Repurposing food and agricultural policies to make healthy diets more affordable, Rome, 2022; and global network against food crises, food security information network, Global report on food crises. Joint analysis for better decisions, 2022.

Nunez Ferrer, J. (2020): The EU's Public Procurement Framework. How is the EU's Public Procurement Framework contributing to the achievement of the objectives of the Paris Agreement and the Circular Economy Strategy?

United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: the 2022 Revision, New York, 2022.

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