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CIRCULAR INSIGHTS SERIES

Examining how single-use packaging used in the sale of fruit and vegetables can be reduced

Circular Insights

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ENVIRONMENTAL PROTECTION AGENCY

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Glossary

Term	Definition
Biodegradable packaging	Packaging of such a nature that it is capable of undergoing physical, chemical, thermal or biological decomposition such that most of the finished compost ultimately decomposes into carbon dioxide, biomass and water. Oxo-degradable plastic packaging shall not be considered as biodegradable[1]
Bioplastics	Plastics that are either made from renewable resources ('bio-based'), are biodegradable, are made through biological processes or a combination of these[2]
Bio-waste	Biodegradable garden and park waste, food and kitchen waste from households, offices, restaurants, wholesale, canteens, caterers and retail premises and comparable waste from food processing plants[3]
Circular economy	An economic model and the policies and practices which give effect to that model in which—(a) production and distribution processes in respect of goods, products and materials are designed so as to minimise the consumption of raw materials associated with the production and use of those goods, products and materials, (b) the delivery of services is designed so as to reduce the consumption of raw materials, (c) goods, products and materials are kept in use for as long as possible thereby further reducing the consumption of raw materials and impacts harmful to the environment, (d) the maximum economic value is extracted from goods, products, and materials by the persons using them, and (e) goods, products and materials are recovered and regenerated at the end of their useful life[4]
Circular material use rate (CMUR)	The circular material use rate measures the share of material recovered and fed back into the economy — thus saving extraction of primary raw materials — in overall material use. The indicator includes flows of materials but it does not include flows of water. It includes flows of fossil fuels and energy products. It is defined as the ratio of the circular use of materials to an indicator of the overall material use.[5]
Cold chain	A term applied to food handling and distribution where the product is maintained at suitable temperature conditions all the way from harvesting, through the cooling or freezing process to the point of sale[6]
Composite packaging	Packaging made of two or more layers of different materials which cannot be separated by hand and form a single integral unit, consisting of an inner receptacle and an outer enclosure, that it is filled, stored, transported and emptied as such[1]

Term	Definition
Compostable packaging	Packaging that biodegrades only in industrially controlled conditions or that is capable of undergoing biological decomposition in such conditions, including, if necessary, with physical treatment, anaerobic digestion, resulting ultimately in conversion of the packaging into carbon dioxide or, in the absence of oxygen, methane, and mineral salts, biomass and water, and does not hinder or jeopardise the separate collection and the composting and anaerobic digestion process.[7] This is distinguished from 'home compostable packaging', as defined below.
Dematerialisation	The absolute or relative reduction in the quantity of materials used and/or the quantity of waste generated in the production of a unit of economic output[8]
Disposal	Disposal (a) means any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy, and (b) without prejudice to the generality of paragraph (a), includes the disposal operations listed in the Third Schedule [of the Waste Management Act 1996, as amended].[3]
Ethylene	A colourless flammable gaseous unsaturated hydrocarbon, C2H4, that is found in coal gas, can be produced by pyrolysis of petroleum hydrocarbons, and occurs in plants functioning especially as a natural growth regulator that promotes the ripening of fruit[9]
Extended producer responsibility (EPR) scheme	A set of measures taken by Member States to ensure that producers of products bear financial responsibility or financial and organisational responsibility for the management of the waste stage of a product's life cycle[3]
Food	Any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans[10]
Food contact material (FCM)	Materials and articles […] which in their finished state; (a) are intended to be brought into contact with food, (b) are already in contact with food and were intended for that purpose, or (c) can reasonably be expected to be brought into contact with food or to transfer their constituents to food under normal or foreseeable conditions of use[11]
Food waste	All food as defined in Article 2 of Regulation (EC) No 178/2002 of the European Parliament and of the Council that has become waste.[3,10] The EC further defines food waste as any food that has become waste under these conditions: (1) it has entered the food supply chain, (2) it then has been removed or discarded from the food supply chain or at the final consumption stage, (3) it is finally destined to be processed as waste. Therefore, food waste can comprise items which include parts of food intended to be ingested (edible food) and parts of food not intended to be ingested (inedible food).[12]

Term	Definition
Home compostable packaging	Packaging that can biodegrade in noncontrolled conditions that are not industrial scale composting facilities and the composting process of which is performed by private individuals with the aim of producing compost for their own use[7]
Lifecycle assessment (LCA)	The compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle[13]
Logistics	The overall process of managing how resources are acquired, stored and transported to a final destination[14]
Municipal waste	Municipal waste means: (a) mixed waste and separately collected waste from households, including paper and cardboard, glass, metals, plastics, bio-waste, wood, textiles, packaging, waste electrical and electronic equipment, waste batteries and accumulators, and bulky waste, including mattresses and furniture; (b) mixed waste and separately collected waste from other sources, where such waste is similar in nature and composition to waste from households. Municipal waste does not include waste from production, agriculture, forestry, fishing, septic tanks and sewage network and treatment, including sewage sludge, end-of-life vehicles or construction and demolition waste. This definition is without prejudice to the allocation of responsibilities for waste management between public and private actors.[3]
Organic product	A product resulting from organic production methods that comply with Regulation (EU) 2018/848; other than a product produced during the conversion period referred to in Article 10 of the Regulation. The products of hunting or fishing of wild animals are not considered as organic products.[15]
Oxo-degradable plastic	Plastic materials that include additives which catalyse the fragmentation of the plastic material into micro-fragments[4]
Packaging	Any material, container or wrapping, used for or in connection with the containment, transport, handling, protection, promotion, marketing or sale of any product or substance, including such packaging as may be prescribed[3]
Plastic	A polymer within the meaning of Article 3(5) of Regulation (EC) No. 1907/2006, to which additives or other substances may have been added[4]
Preparing for reuse	Checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing[3]
Primary (sales) packaging	Packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase[16]

Term	Definition
Recovery	Recovery (a) means any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy, and (b) without prejudice to the generality of paragraph (a), includes the recovery operations listed in the Fourth Schedule [of the Waste Management Act 1996, as amended].[3]
Recycling	Recycling—(a) subject to paragraph (b), means any recovery operation by which waste materials are reprocessed into products, materials or substances, whether for the original or other purposes, including the reprocessing of organic material, (b) does not include— (i) energy recovery, and (ii) the reprocessing into materials that are to be used as fuels or for backfilling operations.[3]
Respiration	The sum total of the physical and chemical processes in an organism by which oxygen is conveyed to tissues and cells, and the oxidation products, carbon dioxide and water, are given off[17]
Reusable alternative item	A re-usable container, re-usable cup or re-usable packaging that is an alternative to a single-use container, single-use cup or single-use packaging, as the case may be[4]
Reusable packaging	Packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle multiple trips or rotations by being refilled or reused for the same purpose for which it was conceived[1]
Reuse	Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived[3]
Secondary (grouped) packaging	Packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale; it can be removed from the product without affecting its characteristics[16]
Single-use packaging	Packaging which—(a) is conceived, designed or placed on the market, and (b) is not re-usable, other than packaging which falls within a class of packaging specified in regulations under section 11(1) as being a class of packaging excepted from this definition[3]
Single-use plastic product	A product that is made wholly or partly from plastic and that is not conceived, designed or placed on the market to accomplish, within its life span, multiple trips or rotations by being returned to a producer for refill or re-used for the same purpose for which it was conceived[18]
Supply chain	The cumulative network of people, entities, activities, information and resources involved in moving raw materials, components and finished products from original suppliers to end users[19]

Term	Definition
Tertiary (transport) packaging	Packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packagings in order to prevent physical handling and transport damage. Transport packaging does not include road, rail, ship and air containers[16]
Traceability	The ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be incorporated into a food or feed, through all stages of production, processing and distribution[10]
Transpiration	A plant's loss of water, mainly through the stomata of leaves[20]
Waste	Any substance or object which the holder discards or intends or is required to discard[3]
Waste management	The collection, transport, recovery including sorting, and disposal of waste, including the supervision of such operations and the after-care of disposal sites, and including actions taken as a dealer or broker[3]
Waste prevention	Measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of hazardous substances in materials and products[3]

Acronyms

Acronym	Definition
B2B	Business-to-business
BBD	Best before date
CAP	Common Agricultural Policy
CEAP	Circular Economy Action Plan
CIS	Circular Insights Series
CMUR	Circular material use rate
CSA	Community supported agriculture
CSO	Central Statistics Office
CO_2	Carbon dioxide
DAFM	Department of Agriculture, Food and the Marine
DCU	Dublin City University
EC	European Commission
EMF	Ellen MacArthur Foundation
EPA	Environmental Protection Agency
EPR	Extended Producer Responsibility
ESL	Electronic shelf label
EU	European Union
FCM	Food contact material
FSAI	Food Safety Authority of Ireland
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organisation for Standardisation
LCA	Life cycle assessment
MAP	Modified atmosphere packaging
OECD	Organisation for Economic Cooperation and Development
PaaS	Product-as-a-service
PCL	Poly(caprolactone)

Acronym	Definition
PE	Polyethylene
PET	Polyethylene terephthalate
PLA	Polylactic acid
PLU	Price look-up (code)
PP	Polypropylene
PVC	Polyvinyl chloride
PPWD	Packaging and Packaging Waste Directive
PPWR	Packaging and Packaging Waste Regulation
QR	Quick-response (code)
RFID	Radio frequency identification
SDG	(United Nations) Sustainable Development Goal(s)
SFSC	Short food supply chains
SKU	Stock-keeping unit (code)
SRS	Swedish Return System (*Svenska Retursystem*)
UK	United Kingdom
UN	United Nations
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organisation
USA	United States of America
US FDA	United States Food and Drug Administration
WAPCE	Waste Action Plan for a Circular Economy
WEEE	Waste electrical and electronic equipment
WHO	World Health Organisation
WRAP	Waste and Resources Action Programme

Foreword

The Environmental Protection Agency (EPA) leads the Circular Economy Programme, which is a statutory requirement under the Circular Economy and Miscellaneous Provisions Act 2022. The vision for the programme is an Ireland in which the circular economy ensures that everyone uses less resources and prevents waste to achieve sustainable economic growth.

The Circular Economy Programme has regulatory activities (authorisation of waste sector, by-product and end-of-waste regulation), provides evidence (reporting of national statistics and delivering insights studies) and works with others (including providing funding supports for innovation & demonstration, developing and implementing statutory programmes and plans such as national food waste prevention programmes and the National Hazardous Waste Management Plan).

The Circular Economy Programme is commissioning a series of 'Circular Insights' studies on emerging and priority topics to build evidence and fill knowledge gaps to support circular economy policy. Through analysis of data, literature review, stakeholder interviews and assessment of best and emerging practices, it is intended that these studies will offer insights relevant to policy makers, business and other circular economy practitioners and contribute to national discussions on circular economy.

This Circular Insights study examines how single-use packaging used in the sale of fruit and vegetables can be reduced. The study has been carried out by Arup under contract to the EPA.

Executive Summary

This study, undertaken as part of the EPA's Circular Insights Series, examines how single-use packaging used in the sale of fruit and vegetables can be reduced. The completion of this study is to fulfill a statutory requirement under the Circular Economy and Miscellaneous Provisions Act 2022[4]. Its objectives are to (i) gather information and insights on the types of single-use packaging used to bring fruit and vegetables to the point of sale; (ii) gather information on the role of producers, wholesalers/distributors and retailers in specifying the type and use of single-use packaging in the sale of fruit and vegetables; and (iii) identify options for reduction in single-use packaging in the sale of fruit and vegetables. The study has been informed by a literature review and engagement with key stakeholders.

Current trends of packaging use in Ireland and internationally represent an unsustainable use of resources and an obstacle to the transition to a circular economy, driving increasing consumption of virgin materials, waste generation and associated environmental impacts. In Europe, packaging alone represents over a third (36%) of municipal solid waste.[21] Packaging waste in the EU has been increasing steadily over the last decade.[22] Food packaging accounts for a significant proportion of packaging.[23, 24, 25] Demand for packaging may be expected to increase in line with population growth and food demand in Ireland and globally.[23, 24, 26, 27]

This study has identified key types, materials and functions of single-use packaging used in the supply chain of fresh fruit and vegetables, as summarised below. The quantities of packaging placed on the market and/or packaging waste generated associated with single-use packaging of fresh fruit and vegetables in Ireland is not known. Packaging used in the supply chain – single-use and reusable – fulfils a variety of functions. From an environmental perspective, the most important function of packaging is the prevention of food waste, a significant source of anthropogenic greenhouse gas emissions (approx. 8-10% globally).[28]

Single-use packaging of fresh fruit and vegetables – overview of types, materials and functions

Types	Materials	Functions
• Sticky labels • Adhesive bands • Trays, tubs and cups in various materials (including plastic punnets) • Plastic films • Plastic and paper tags • Plastic and paper bags • Plastic and bio-based nets • Cardboard boxes • Wooden boxes	• Petroleum-based plastics • Bio-based plastics • Adhesives • Paper • Paperboard • Cardboard • Wood • Composite materials (including biocomposites) • Bio-based fibres • Metals	• Protection from damage and spoilage (including prevention of food waste) • Compatibility with supply chain processes and logistics • Compliance with food safety requirements • Provision of information (including marketing) • Grouping of produce to create a sales unit • Meeting consumer expectations (e.g., convenience) • Separation of organic produce (not strictly required)

The supply chain of fresh fruit and vegetables for retail sale in Ireland is an integrated, global network of actors, including producers, packaging suppliers, wholesalers, distributors, retailers and consumers (Figure 1). Fresh fruit and vegetables consumed in Ireland come from a mix of domestic production and

imports. According to Teagasc, Ireland produces about 60% of its vegetables, with the remainder being imported; while data from Eurostat indicates that the majority of Ireland's fruit and vegetables (approx. 83%) are imported.[29, 30] Imported fruit and vegetables are predominantly from within the EU, but Ireland imports fresh produce from over 200 territories globally, highlighting the complexity of the supply chain.[31]

The food retail sector in Ireland is highly competitive. The five largest retailers (Dunnes Stores, SuperValu, Tesco, Aldi and Lidl) have a combined market share of over 90%.[32] Large retailers are key actors influencing the specification of the packaging. They engage proactively with suppliers, providing guidelines regarding acceptable packaging formats. Smaller retailers have comparatively less purchasing power and may rely on larger retailers to create demand for packaging reduction options, such as loose produce.

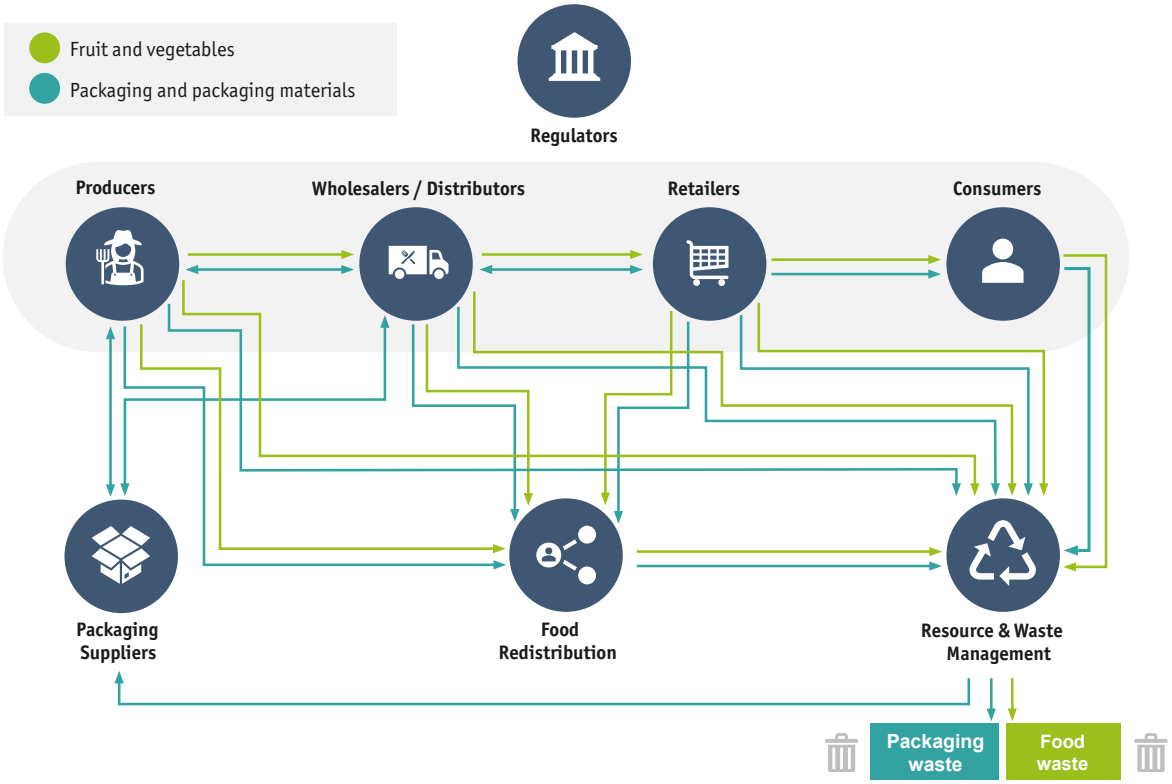

Figure 1: Fresh produce supply chain – overview

Based on the literature review and stakeholder engagement, key options for reducing single-use packaging of fresh fruit and vegetables were identified and investigated, as summarised in Figure 2 below: dematerialisation (including lightweighting of packaging, loose produce and laser labelling), reusable packaging (including business-to-business (B2B) pooling systems and consumer-level reuse) and short food supply chains.

Dematerialisation refers to options to reduce the materiality of packaging (e.g., through lightweighting) and, where appropriate, to eliminate packaging entirely (e.g., by selling loose produce or replacing sticky labels with alternatives such as laser labelling).

Lightweighting is a well-established practice in the packaging industry, promoted by weight-based extended producer responsibility (EPR) fees. It is a class of eco-efficiency measure that includes efforts to reduce packaging thickness ('downgauging') and dimensions (e.g., by reducing void space or redundant

parts). Lightweighting provides an opportunity to reduce the resource intensity of packaging in cases in which it cannot be fully eliminated. However, stakeholders have highlighted that the lightest packaging is not necessarily always the most sustainable or functional packaging, highlighting the need for a whole lifecycle perspective.

In some instances, non-essential primary packaging may be eliminated entirely in favour of **loose produce**. This approach also allows consumers to purchase the exact amount needed, potentially reducing household food waste. However, not all fruit and vegetables are suited to loose sale due to high perishability or fragility. Stakeholders have also highlighted that there may be little to no economic incentive for retailers to switch from pre-packaged to loose produce, due to the potential commercial impact of consumers purchasing less or switching to retailers that offer pre-packaged produce.

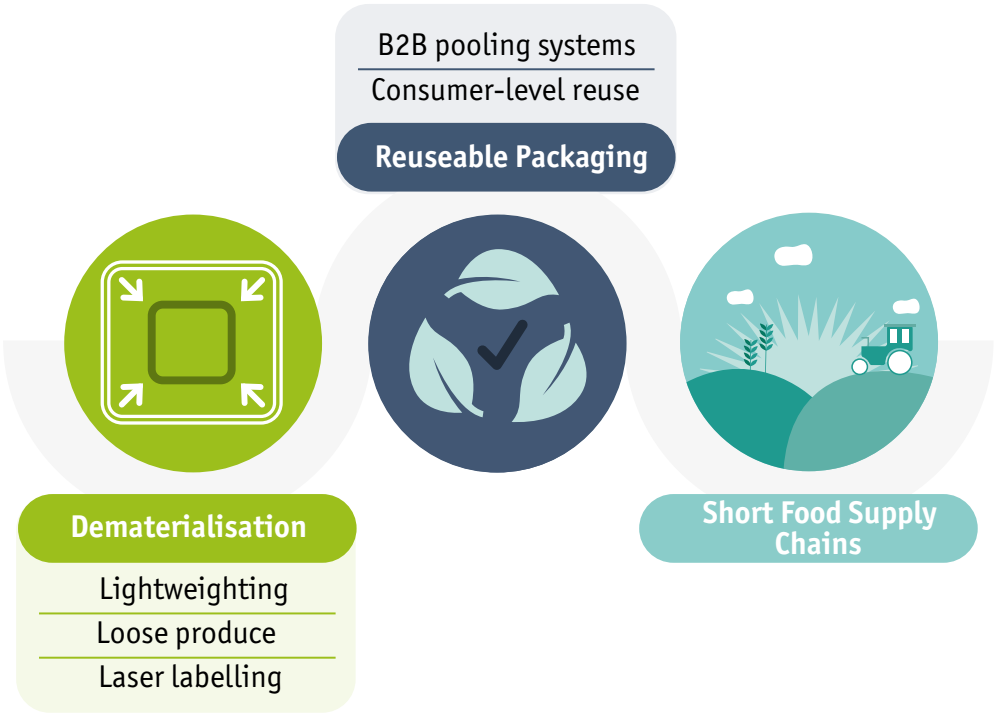

Figure 2: Options for reducing single-use packaging in the supply chain of fresh fruit and vegetables

Laser labelling is an alternative to sticky labels, whereby laser technology is used to mark the skin of produce with key information without affecting quality or shelf-life. This approach could be particularly useful for produce that tends to shed sticky labels and for differentiating organic produce. Laser labelling has been adopted by several retailers elsewhere in Europe and the UK but is yet to be implemented in Ireland – and the upfront capital costs may be high. The approach may not be suitable for all fruit and vegetables that typically have sticky labels (e.g., citrus), and may not be accepted by consumers on produce with edible skin.

Reusable packaging refers to *"Packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle multiple trips or rotations by being refilled or reused for the same purpose for which it was conceived".*[1] Reusable packaging options include B2B pooling systems and consumer-level reuse.

In **B2B pooling systems**, a third-party (the 'pooler') provides clean, ready-to-use reusable packaging – typically durable plastic crates and/or plastic or wooden pallets – to the supply chain. The reusable packaging is used to convey produce from producer to retailer and may be used directly in retail shelf displays. Through reverse logistics, the pooler maintains ownership and responsibility for cleaning and maintenance of the reusable packaging throughout the lifecycle. This closed loop system provides an

alternative to single-use secondary and tertiary packaging, such as cardboard and wooden boxes.

Consumer-level reuse is also an option, whereby consumers themselves use reusable packaging to gather loose produce at the point of sale. This approach is complementary to loose produce and is already being adopted by a number of retailers in Ireland. Potential challenges include ensuring sufficient levels of reuse, and overcoming the additional time and effort required on the part of the consumer.

A number of publications have noted that **short food supply chains** for fresh fruit and vegetables may involve less packaging while offering a range of environmental, social and economic co-benefits. However, little primary research comparing the amount of packaging in short and long food supply chains was identified.

The findings of this study indicate that opportunities exist to reduce or eliminate some types of single-use packaging currently used for fruit and vegetables in Ireland, and to improve the efficiency of reusable packaging systems in the supply chain. Its findings also underline the need to adopt a whole supply chain perspective that ultimately aims to reduce the net lifecycle environmental impacts of the supply chain, including indirect impacts on food waste.

Based on the findings of this study, the following options are recommended:

1. Promote the sale of loose produce by addressing known barriers and further developing the evidence base for its adoption (including through pilots and trials, voluntary agreements and education and awareness);
2. Adopt a system or systems for reusable secondary and tertiary packaging;
3. Investigate potential alternative labelling technologies suitable for use in the Irish fresh produce supply chain; and
4. Investigate the potential of short food supply chains to optimise single-use packaging reduction for crops suited to commercial production in Ireland.

Further details regarding these recommendations are provided in Section 4 of this report.

1. Introduction

1.1 BACKGROUND

The circular economy offers an alternative to the prevailing linear 'take-make-use-dispose' model of resource use. In a circular economy, waste and pollution are eliminated, products and materials are circulated at their highest value, and nature is regenerated.[33]

Ireland is at a turning point for the transition from a linear to a circular economy.[34] In recent years, several interventions including government-led waste prevention and circular economy initiatives, government funding schemes, and the introduction of national circular economy policies and action plans are supporting Ireland's transition to a circular economy. While Ireland has introduced legislation and policies to promote circularity in recent years, its circular material use rate (CMUR) is low compared with the Netherlands (27.5%), Belgium (22.2%) and France (19.3%).[35] The Government has committed to significantly reducing Ireland's circularity gap, both in absolute terms and relative to other Member States.[36] The CMUR is a 'whole of economy' metric expressing recycling and recovery tonnage as a percentage of total materials/resources extracted and used in an economy including imports. Ireland's low CMUR rate is explained in part by our open economy with a strong agricultural sector and high level of exports. For other circular economy indicators, Ireland is more closely aligned to other Member States (e.g. Ireland's municipal recycling rate is 41% compared to EU average 46%).

'Packaging' is legally defined as *"any material, container or wrapping, used for or in connection with the containment, transport, handling, protection, promotion, marketing or sale of any product or substance, including such material, container or wrapping as may be prescribed"*.[4] Single-use packaging is further defined as *"packaging which— (a) is conceived, designed or placed on the market, and (b) is not re-usable, other than packaging which falls within a class of packaging specified in regulations under section 11(1) as being a class of packaging excepted from this definition"*.[4] For various reasons, packaging is used at one or more stage(s) in the supply chain of many goods.

Current, predominantly linear patterns of packaging use represent an unsustainable use of resources and an obstacle to the transition to a circular economy, driving increasing consumption of virgin materials and waste generation. For example, the global packaging industry is the largest consumer of plastics and the main source of plastic waste.[23] A similar pattern is observed in Europe, where packaging production is the largest consumer of plastics, and packaging alone represents over a third (36%) of municipal solid waste.[21]

Packaging and packaging waste give rise to a range of environmental impacts, which vary depending on the nature of the packaging, including materials used. Direct and indirect environmental impacts arise throughout the packaging product lifecycle, from raw material production and extraction, to manufacturing, transportation, use and end-of-life management.[23, 37, 38] These include the consumption of virgin raw materials, greenhouse gas emissions and solid waste generation.[23]

Packaging waste is a growing problem in Europe. Packaging waste in the EU has been increasing steadily over the last decade.[22] Between 2010 and 2021, the weight of packaging waste generated per capita in the EU increased by 22.5%. In 2021, 84.3 million tonnes of packaging waste were generated in the EU Member States – an increase of 6% relative to 2020.[35]

Ireland's packaging waste generation is on an upward trend in recent years, with an increase of approx. 25% between 2016 and 2021, when Ireland generated 246.1 kg of packaging waste per capita.[35, 39] Ireland's packaging recycling rate has been on a downward trend in recent years, decreasing from 67% in 2016 to 58% in 2021. While Ireland is achieving high levels of recycling for paper and cardboard

(73% in 2021) (the largest share of packaging waste), meeting future targets for recycling of plastic packaging waste (the next greatest share) poses a major challenge.[39] In 2021, less than a third (28%) of plastic packaging waste generated in Ireland was recycled – substantially below the EU 2025 target of 50%.[16] The majority of Ireland's plastic packaging waste is incinerated. This has been attributed to poor segregation in homes and businesses.[40]

Food packaging accounts for a significant proportion of product packaging.[23, 24] A 2009 study estimated that food packaging represented approx. 41% of all packaging use in the USA at that time, while a more recent (2020) study states that food packaging accounts for 50% of all fossil-based plastics.[23, 25]

Without changes to patterns of packaging use in global food systems, demand for food packaging and generation of packaging waste may be expected to increase in line with demand for food. Between 2010 and 2050, global food demand is projected to increase by between 35-56% as the global population grows.[26] In Ireland, the Central Statistics Office has projected population growth in the resident population from 4.7 million in 2016 to between 5.6 – 6.7 million in 2051 (growth of 17.7 – 41.2%) under different scenarios.[27]

In accordance with circular economy principles and the waste hierarchy (Figure 3), packaging waste prevention is of a higher order of preference than strategies such as recycling, recovery or disposal.[41] A number of sources have highlighted that reliance on increasing rates of recycling alone cannot solve the problems of food packaging.[38] There are a number of challenges associated with recycling, including technological and economic constraints, reliance on infrastructure in developing countries, and the energy and resources required to facilitate recycling.[38] Furthermore, increasing rates of recycling are failing to keep pace with increasing rates of packaging waste generation.[39] As noted by the European Parliament, *"Waste prevention is an important challenge in all Member States, including those with high recycling rates"*.[42]

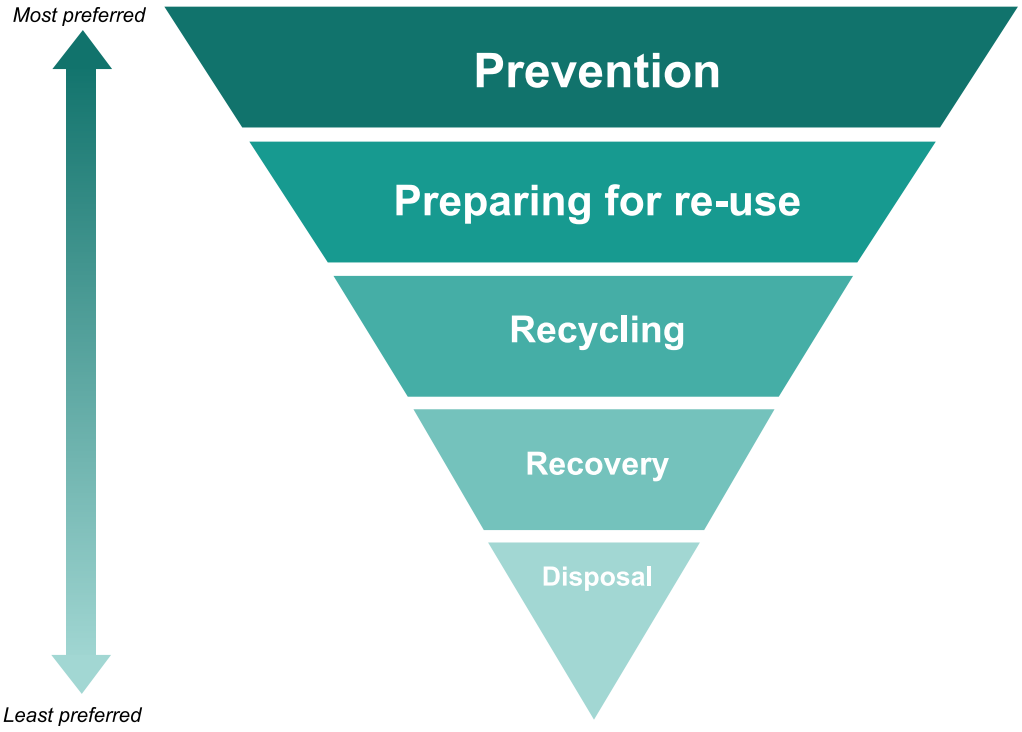

Figure 3: Waste hierarchy (adapted from European Parliament & Council of the EU, 2008)

Material substitution is one approach to mitigating the environmental and human health impacts of food packaging. For example, non-renewable petroleum-based plastics may be replaced with biodegradable, bio-based plastics in food packaging.[38] Lifecycle assessment (LCA) may be used to compare the lifecycle environmental impacts of alternative packaging materials for a given application, looking at key environmental performance indicators. Material substitution using more sustainable alternatives can deliver positive impacts, including decarbonisation of packaging.[43] However, a number of sources have highlighted potential negative impacts associated with the use of bio-based alternatives, including ecological impacts of feedstock production for biopolymers, and carbon emissions associated with increased composting.[38, 44] Material substitution does not however address the challenge of reducing single use packaging.

While recycling and bio-based materials have roles to play in tackling the challenges of food packaging waste, in the context of increasing demand for fresh produce and packaging requirements of globalised supply chains, solutions are needed to reduce the volume of packaging used and packaging waste generated overall, including switching from single-use to reusable packaging and dematerialisation.

'Reusable packaging' refers to *"Packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle multiple trips or rotations by being refilled or reused for the same purpose for which it was conceived"*.[1] There is an increasing focus on reusable, refillable and returnable packaging solutions as circular alternatives to single-use equivalents at various stages in food supply chains. These include business-to-business (B2B) and business-to-consumer (B2C) models, including centralised reusable packaging pooling systems.[45, 46] Repak have highlighted the potential benefits of reusable secondary and tertiary packaging formats in Ireland, including pallets and crates.[47]

However, reusable packaging represents a tiny proportion of all packaging placed on the market in Ireland – approximately 1% in 2021, according to data compiled by Repak.[39]

Policies at European Union and national levels seek to address the challenge of single-use packaging. Packaging is identified as one of seven key product value chains in the EC's Circular Economy Action Plan (CEAP) under the EU Green Deal.[48] The Green Deal and the CEAP set out the Council's objective to ensure that all packaging in the EU is reusable or recyclable in an economically feasible way by 2030.[49] The CEAP identifies a range of measures to support the achievement of this objective, including a review of the Packaging and Packaging Waste Directive (PPWD).[16]

The PPWD, adopted in 1994 and amended in 2018 by Directive (EU) 2018/852, requires Member States to take measures to prevent the generation of packaging waste. It sets out mandatory minimum requirements for all packaging placed on the EU market and requires that packaging volume and weight be limited to the minimum adequate amount to maintain the necessary level of safety, hygiene and acceptance for the packed product and the consumer.[16]

On 4 March 2024, the European Parliament and Council reached a provisional political agreement on a proposed Packaging and Packaging Waste Regulation (PPWR) to augment the PPWD.[7, 50] The proposal aims to support the circular economy in Europe by tackling the increase in packaging waste and harmonising the internal (EU) market for packaging. It aims to minimise packaging waste generation by establishing binding packaging re-use targets, restricting certain types of single-use packaging and requiring economic operators to minimise packaging used. Key provisions under the proposed Regulation are highlighted below.

Key provisions of relevance under proposed Packaging and Packaging Waste Regulation

- Requirement for sticky labels for fruit and vegetables to be compostable within three years of entry into force;
- Requirement for packaging to be designed so as to minimise its volume and weight while maintaining its functionality and recyclability;
- Ban on the use of single-use plastic packaging for unprocessed fresh fruit and vegetables under 1.5kg from 2030; and
- Minimum targets for the use of reusable packaging in the supply chain for 2030 and 2040.

The Single-use Plastics Directive (Directive (EU) 2019/904) was adopted in 2019. Its objectives are to prevent and reduce the impact of certain single-use plastic products on the environment, in particular the marine environment, and on human health, as well as to promote the transition to a circular economy with innovative and sustainable business models, products and materials. Under the Directive, certain single-use plastic products were banned in July 2021, including cotton bud sticks, cutlery, straws, beverage stirrers, balloon sticks and expanded polystyrene food and drink containers. Article 8 of the Directive ensures that extended producer responsibility (EPR) schemes are established for certain single-use plastic products, including containers for food which is ready to be consumed without any further preparation, such as cooking, boiling or heating; and lightweight plastic carrier bags, as defined in Directive 94/62/EC.

At the national level, under the Waste Action Plan for a Circular Economy (WAPCE), the Government has committed to reducing over-packaging and packaging waste through a range of measures, including working with retailers to end the sale of multi-buy packs to prevent over-buying by consumers; working with retailers to encourage the provision of refill options; and considering restricting packaging for certain applications, particularly where reusable packaging or packaging-free alternatives are appropriate.[51] This study focusses specifically on options to reduce single-use packaging used in the supply chain of fresh fruit and vegetables. For this food group, reducing single-use packaging poses a particularly complex challenge due to trade-offs with other considerations, not least food waste prevention.[52]

1.2 AIMS AND OBJECTIVES

The completion of this study is to fulfill a statutory requirement under Section 14(7) of the Circular Economy and Miscellaneous Provisions Act 2022 ('the Act' hereafter), which states that: *"The Minister shall, not later than 12 months after the coming into operation of this subsection, publish, on a website maintained by or on behalf of the Minister or the Government, a report prepared by or on behalf of the Minister examining how single-use packaging used in the sale of fruit and vegetables can be reduced."*[4]

The overarching aim of this study is to produce a report examining how single-use packaging used in the sale of fruit and vegetables can be reduced, in accordance with the requirements of the Circular Economy and Miscellaneous Provisions Act 2022. The objectives of the study are set out below.

Study Objectives

- Gather information and insights on the types of single-use packaging used to bring fruit and vegetables to the point of sale;
- Gather information on the role of producers, wholesalers/distributors and retailers in specifying the type and use of single-use packaging in the sale of fruit and vegetables; and
- Identify options for reduction in single-use packaging in the sale of fruit and vegetables.

2. Methodology

This study was informed by two principal sources of information: a literature review of relevant publications and stakeholder engagement comprising a series of workshops and a survey. Insights gathered during both stages form the basis of the conclusions and recommendations presented herein.

2.1 LITERATURE REVIEW

A literature review was undertaken of relevant publications, including national and EU law and policy; peer-reviewed academic literature; publications from key organisations; and newspaper articles from reputable sources. Sources using primary data were used preferentially, where available. A register of documents identified and reviewed as part of the literature review was maintained, including links to publications and citations using Harvard referencing style. The literature review was structured around three focus areas, as follows. Relevant case studies were identified throughout the literature review process.

Literature Review – Focus Areas

- Identify and describe the types and functions of packaging used in the fruit and vegetable supply chain.
- Identify and describe the role of key stakeholders in the fruit and vegetable supply chain.
- Identify options for reducing the use of single-use packaging in the supply chain of fruit and vegetables, having regard to quality, shelf-life, food safety and waste prevention; and considering measures implemented in other countries.

2.2 STAKEHOLDER ENGAGEMENT

Stakeholder engagement, comprising workshops and an anonymous survey, was undertaken with key stakeholders to inform this study. A selection of potential stakeholders was identified, representing key stages in the fruit and vegetable supply chain; as well as stakeholders of relevance to packaging, including organisations representing enforcement, policy advocacy and research. The authors would like to thank the stakeholders engaged, as listed in **Appendix A**, for their participation in the study. The anonymous stakeholder survey was circulated to 37 persons across the organisations listed in **Appendix A**. A total of 16 responses were received.

3. Insights

This section presents the insights gathered during the literature review and stakeholder engagement in relation to the following key topics:

- **Types and materials of packaging** used in the supply chain of fresh fruit and vegetables (Section 3.1);
- **Functions of packaging** used in the supply chain of fresh fruit and vegetables (Section 3.2);
- **The supply chain** of fresh fruit and vegetables for retail sale in Ireland, with a focus on the specification and use of packaging (Section 3.3); and
- **Options for reducing single-use packaging** used in the supply chain of fresh fruit and vegetables (Section 3.4).

In each case, the findings of the literature review are presented first, followed by an overview of stakeholder insights. In Sections 3.2 and 3.4, summaries are provided, consolidating insights from the literature review and stakeholder engagement regarding the functions of packaging and options for reducing single-use packaging, respectively. Unless otherwise stated, references to 'packaging' in this section refer to packaging used in the supply chain of fresh fruit and vegetables.

3.1 PACKAGING TYPES AND MATERIALS

3.1.1 Literature Review

Key types of packaging identified during the literature review, are detailed in Table 1.[24, 38, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66] Of these, key types of single-use packaging are highlighted below. As highlighted in Table 1, a variety of materials are used in packaging. Principal materials used are highlighted below, and described in **Appendix B**.

The PPWD distinguishes between primary, secondary and tertiary packaging.[16] Primary (or sales) packaging refers to *"packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase"*. Secondary (or grouped) packaging refers to *"packaging conceived so as to constitute at the point of purchase a grouping of a certain number of sales units whether the latter is sold as such to the final user or consumer or whether it serves only as a means to replenish the shelves at the point of sale"*, which *"can be removed from the product without affecting its characteristics"*. Tertiary (or transport) packaging refers to *"packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packaging in order to prevent physical handling and transport damage"* and does not include *"road, rail, ship and air containers"*. Packaging types identified in Table 1 are categorised according to the class of packaging as per the PPWD.

Key types of single-use packaging used in the supply chain of fresh fruit and vegetables	
• Sticky labels • Adhesive bands • Trays, tubs and cups in various materials (including plastic punnets) • Plastic films	• Plastic and paper tags • Plastic and paper bags • Plastic and bio-based nets • Cardboard boxes • Wooden boxes

Principal materials used in packaging in the supply chain of fresh fruit and vegetables	
• Petroleum-based plastics (e.g., PE, PET, PP)	• Cardboard
• Bio-based plastics (e.g., PLA)	• Wood
• Adhesives	• Composite materials (including biocomposites)
• Paper	• Bio-based fibres
• Paperboard	• Metals

3.1.2 Stakeholder Insights

Additional considerations that arose during stakeholder engagement are as follows:

- On plastic punnet trays, hinged or detachable plastic lids are increasingly being replaced by 'top seal' plastic films.
- Recyclable plastic nets may create a challenge for recycling, due to a tendency to become tangled in moving parts (e.g., axles) of equipment used in recycling infrastructure.
- In some cases, specific packaging formats have been developed for types of fruit and vegetables. The 'banana box' is a specific type of cardboard box for the transportation of bananas, developed by Chiquita in the 1960s, which features holes for ventilation and to allow access to pre-treatment gases.[67] Additional packaging, including a thin sheet of paperboard and a large plastic film wrap, are typically included within the box.[68] Reusable packaging formats have also been developed specifically for the transportation of bananas.[69]
- Due to the propensity of certain produce to shed sticky labels, a particularly strong adhesive is sometimes required (e.g., for melons).

Table 1: Key types of packaging used in the supply chain of fresh fruit and vegetables

Packaging Type		Material(s)	Use Type	Category/ies
	**Sticky labels**	Adhesive Petroleum-based plastic (PP, PE) Paper	Single-use	Primary
	**Bands** (including elastic bands, adhesive and non-adhesive bands)	Rubber (natural or synthetic) Adhesive Paper Petroleum-based plastic (PP, PE) Bio-based plastic (PLA)	Single-use	Primary/ Secondary
	**Trays / tubs / cups** (with or without films, lids, netting or bands; including 'clamshells' and punnet trays)	Petroleum-based plastic (PET, PP) Bio-based plastic Paperboard Cardboard Biocomposite	Single-use	Primary/ Secondary
	**Films** (including shrink-films, film bags and 'top seal' films on trays)	Petroleum-based plastic (PE, PP, PVC) Bio-based plastic (PLA)	Single-use	Primary
	**Bags / sacks** (including bulk bags)	Petroleum-based plastic (PE, PP) Bio-based textile (e.g., cotton, jute) Paper Bio-based plastic	Single-use/ Reusable	Primary/ Secondary/ Tertiary

Packaging Type		Material(s)	Use Type	Category/ies
	**Nets** (including extruded or knitted netting with clips)	Petroleum-based plastic (PP, PE, PET) Bio-based fibre (e.g., cellulose) Metal (clipping wire)	Single-use	Primary
	**Tags** (including 'wine glass tags' attached to nets)	Petroleum-based plastic (PP, PE, PET) Paper	Single-use	Primary
	**Pallet boxes / produce bins** (including 'Dolav bins')	Wood Petroleum-based plastic (PP) Metal	Reusable	Tertiary
	**Crates / boxes** (including foldable boxes, trays, crates and banana boxes)	Petroleum-based plastic Cardboard Wood	Single-use/ Reusable	Primary/ Secondary/ Tertiary
	**Pallets** (including whole and half-pallets)	Petroleum-based plastic Wood Metal	Reusable	Tertiary
	**Ancillary transit packaging protection** (including pallet wrap and netting, straps, angle/corner board, and blankets for stabilisation and protection)	Petroleum-based plastic Cardboard Bio-based textile (e.g., cotton)	Single-use/ Reusable	Tertiary

3.2 FUNCTIONS OF PACKAGING

3.2.1 Literature Review

Packaging used in the supply chain of fresh fruit and vegetables fulfils a variety of functions, as highlighted in the legal definition of packaging as *"any material, container or wrapping, used for or in connection with the containment, transport, handling, protection, promotion, marketing or sale of any product or substance, including such material, container or wrapping as may be prescribed"*.[4] These functions are interacting (i.e., not mutually exclusive) and vary from case to case. Key functions, as identified in the published literature, are described in the following sections. In addition to these direct functions of packaging, a number of sources have identified trends over the last century that may act as underlying drivers of increasing use of packaging, including globalisation of supply chains, increasing global production of plastics, urbanisation, changing household and workplace dynamics, 'on-the-go' lifestyles, demand for out of season produce, and increased reliance on supermarkets.[38, 70]

Protection from Damage and Spoilage

A key function of packaging is protection from damage and spoilage resulting from a range of chemical, biological and physical factors.[23, 71] Each type of fruit and vegetable has different requirements in this regard, depending on intrinsic factors including rates of respiration and transpiration, ethylene production and sensitivity, and fragility.[71] Packaging design is tailored to prevent damage and spoilage throughout the supply chain and can contribute to the prevention of food waste.[23, 71]

Food Waste – A Major Climate Challenge

From an environmental perspective, the most important function of packaging is the prevention of food waste, a significant source of anthropogenic greenhouse gas emissions. According to UNEP, food loss and food waste generates an estimated 8-10% of global greenhouse gas emissions.[28] In the EU, that figure goes up to approximately 16%, according to the EC.[72] The IPCC has highlighted the need to reduce food waste to mitigate the climate impacts of the global food system.[73]

The EPA has estimated that Ireland generated over 750,000 tonnes of food waste in 2021, about a third of which arises in households (Figure 4).[74] In the food retail sector, fresh fruit and vegetables account for the greatest share of food waste generated (34-40%).[75] Research indicates that trade-offs between single-use packaging and food waste are complex and dependent on the type of fruit and vegetable in question.[76, 77] This underlines the need to consider potential impacts on food waste of any efforts to reduce or eliminate single-use packaging of fresh produce.

Food Waste – A Major Climate Challenge

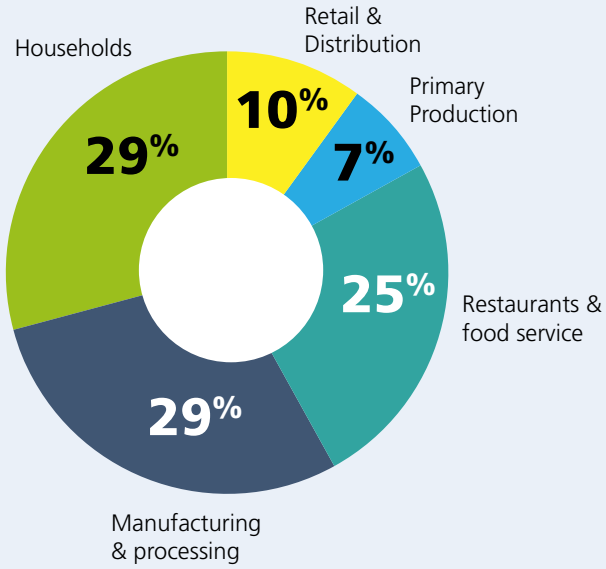

Figure 4: Food waste generated in Ireland in 2021 by supply chain stage[74]

The Irish Government has committed to reducing food waste by 50% by 2030, in line with UN SDG 12.3. The WAPCE addresses the need to balance the prevention of food waste and packaging waste, committing to *"support the design and roll out of packaging developed by retailers and the packaging industry that meets the needs of food preservation without encouraging the generation of packaging waste, especially plastic packaging"*, while working with retailers *"to end the sale of multi-buy packs to prevent over-buying by consumers"*.[51] The National Food Waste Prevention Roadmap 2023-2025 identifies *"sustainable packaging and plastics"* as a key issue in relation to food waste and highlights the potential benefits of *"advances in the bioeconomy"* and increased *"collaboration and research between food companies and others in the supply chain, such as packaging companies"* in this regard.[78]

Compatibility with Supply Chain Processes and Logistics

Packaging needs to be compatible with processes and logistics at various stages, such as harvesting, pre-treatment (where applicable), packing, labelling, storage, palletising and transportation. To promote efficiencies, packaging is often standardised (e.g., 'Euronorm' boxes and crates and 'Euro' pallets).[79, 80] Packaging may also be designed for safe, fast and ergonomic handling by workers. Further considerations in this regard include compatibility with the proposed system of use (i.e., single-use or reusable) and end-of-life management.

Compliance with Food Safety Requirements

Packaging is required to comply with applicable Irish and EU food safety legislation, including that which relates to food contact materials (FCM).[81, 82] Economic operators at all stages in the supply chain have a responsibility to ensure that FCMs are compliant with applicable legislation, and that information on FCMs is incorporated into traceability systems. Planned changes to the EU legislation on FCMs under the EC's Farm to Fork Strategy aim to support the use of innovative and sustainable packaging solutions, including reusable packaging.[83]

Provision of Information

Packaging is also used for the provision of information at various stages in the supply chain.[38, 84] Labelling requirements set out in Irish and EU legislation depend on the type of produce, packaging used and production system (i.e., organic or non-organic).[85, 86, 87, 88, 89] Mandatory information may be provided on secondary or tertiary packaging or, at the point of sale, in close proximity to produce (e.g., on the shelf).

The use of 'best before' dates (BBDs) is not legally required for unprocessed, fresh fruit and vegetables.[90] Some retailers adopt a policy of not printing BBDs on fresh produce to discourage food waste, and the UK-based Waste and Resources Action Programme (WRAP) has recommended that date labels should be removed from uncut fresh produce, except where justified to prevent food waste (e.g., to encourage consumption of produce with a very short shelf life).[91, 92, 93, 94] However, in some instances BBDs may still appear on packaging of fresh produce, where not required.[95] As part of its Farm to Fork Strategy, the EC has committed to revising date marking rules to prevent food waste.[96]

Packaging may also be used to provide information for traceability (e.g., Radio-frequency identification (RFID) tags), pricing (e.g., price look-up (PLU) codes) or marketing. Fruit and vegetables are traditionally minimally branded at the point of sale.[97] However, packaging is increasingly used for marketing, particularly in supermarkets, with noteworthy examples including the recognisable Pink Lady® apple brand, and supermarket branding to differentiate organic produce.[38]

Other

Other functions of packaging identified include prevention of commingling and substitution of organic and non-organic produce; grouping of produce to aggregate smaller items and/or create a sales unit; and meeting consumer expectations (e.g., in terms of convenience). Regarding organic produce, it is required under EU legislation and the national organic food standards that precautionary measures be put in place to avoid commingling and substitution.[88, 89] This often results in organic produce being presented in primary packaging in retail stores, although this is not strictly required.

3.2.2 Stakeholder Insights

Survey respondents were asked to rank in order of importance a number of reasons for single-use packaging used in the supply chain of fruit and vegetables. The aggregated ranking is shown in Figure 5, below. Compliance with food safety/hygiene requirements was the most common first choice of respondents (43.8%), followed by protection from damage and spoilage (37.5%), compatibility with supply chain processes and logistics (12.5%) and provision of information (6.3%).

Survey respondents were also asked to identify any additional reasons for single-use packaging not provided in the list. Additional reasons cited included convenience for consumers and retailers (e.g., faster check-out process) and creation of sales units to increase sales and prevent consumers from 'grading out' produce. In their response to this question, one respondent clarified that, as noted in Section 3.2.1, above, the organic standards do not require the use of single-use packaging of organic produce.

Stakeholder engagement confirmed that the legislative requirements in relation to food labelling, food safety and organic produce do not create a requirement for packaging *per se*. These requirements can be met in the case of loose produce and, as such, are not prohibitive to the adoption of loose produce.

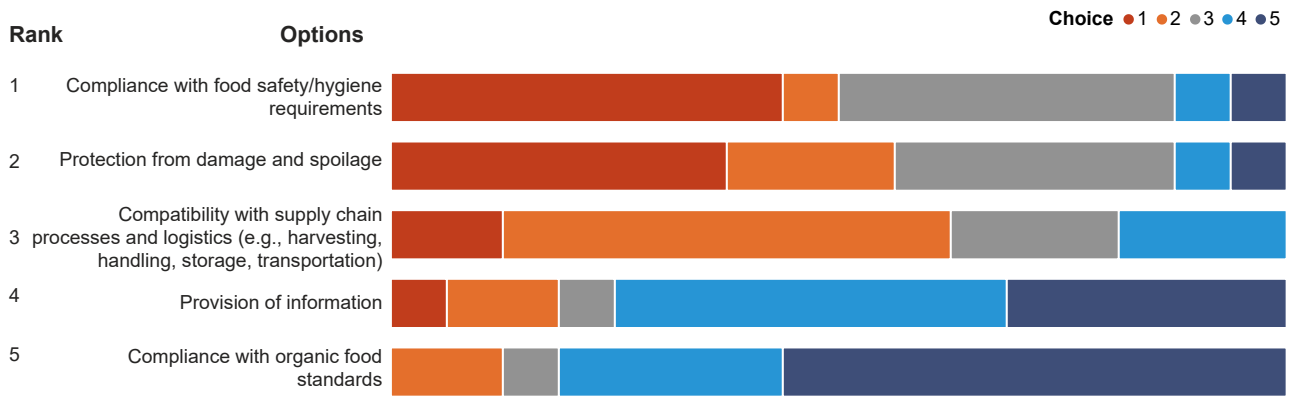

Figure 5: Survey responses: Rank in order of importance: Of the following, what are the most important reasons for single-use packaging used in the supply chain of fruit and vegetables?

3.2.3 Summary

Table 2, below, provides a summary of the packaging functions identified during the literature review and stakeholder engagement.

Table 2: Packaging used in the supply chain of fresh fruit and vegetables – overview of functions identified

Key function	Specific functions identified
Protection from damage and spoilage	• Protection from chemical factors (e.g., gases, moisture, light) • Protection from biological factors (e.g., pathogens, pests) • Protection from physical factors (e.g., crushing, vibration, handling) • Prolonging shelf-life • Prevention of food waste • Prevention of weight loss (retailers often sell by weight)
Compatibility with supply chain processes and logistics	• Compatibility with harvesting, packing, storage, transportation, etc. • Compatibility with equipment used (e.g., sorting tables, filling machines, conveyors, forklifts, pallet wrappers) • Safe, ergonomic and fast handling • Securing tertiary packaging • Standardisation (e.g., punnets designed to fit crates) • Compatibility with proposed system of use (e.g., reuse/single-use) • End-of-life management (e.g., use of recyclable materials)
Compliance with food safety requirements	• Prevention of cross-contamination (e.g., microbes, allergens) • Compliance with legislative requirements for FCMs

Key function	Specific functions identified
Provision of information	• Information required in legislation • Traceability information (e.g., RFID tags, stock-keeping unit (SKU) codes) • Pricing information (e.g., PLU codes) • Marketing and branding • Differentiation of varieties/types
Other	• Grouping of produce to create a sales unit • Meeting consumer expectations (e.g., convenience) • Separation of organic and non-organic produce (not strictly required)

3.3 THE FRESH FRUIT & VEGETABLE SUPPLY CHAIN

3.3.1 Literature Review

The supply chain for fresh fruits and vegetables is an integrated network of actors, each contributing to the journey of produce from farm to consumer (Figure 6). The supply chain is carefully managed to maintain 'full cold chain' and ideal preservation conditions up to the point of sale, when fresh produce is exposed to uncontrolled conditions.[71] Key actors involved in the supply chain are producers, wholesalers and distributors, retailers and consumers. The roles of each these actors in the supply chain are discussed below. Considering organisations in the fresh produce sector in Ireland, a degree of vertical integration is evident, whereby the activities of some organisations cover multiple stages in the supply chain (e.g., production and distribution, wholesaling and retail, production and packaging supply).

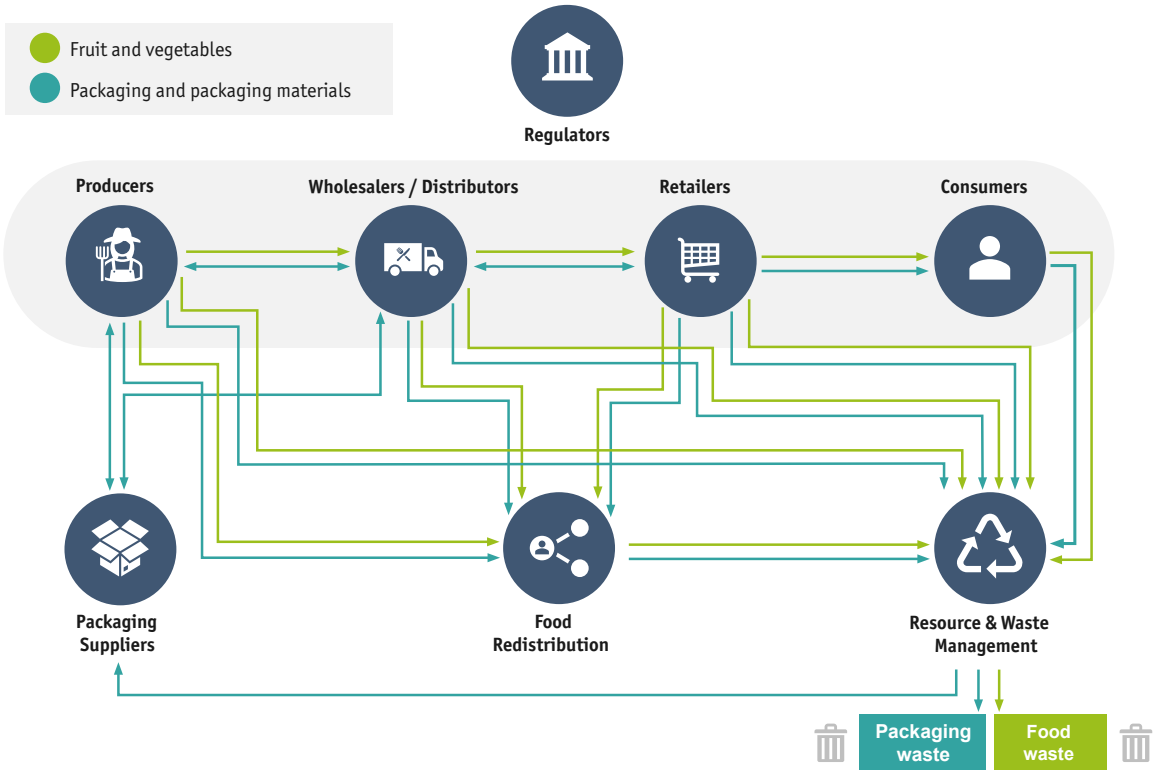

Figure 6: Fresh produce supply chain – overview

Producers

Fresh fruit and vegetables consumed in Ireland come from a mix of domestic production and imports. According to Teagasc, Ireland produces about 60% of its vegetables, with the remainder being imported; while data from Eurostat indicates that the majority of Ireland's fruit and vegetables (approx. 83%) are imported.[29, 30] Imports have increased steadily over the last 60 years, as domestic production has declined. Since the 1960s, there has been a reduction in domestic production of over 70%; while between 1992 and 2020, imports increased by 42%.[31] Due to Ireland's relatively short growing season and consumer demand for out of season produce, imports represent an important part of the supply of fresh produce.[98]

The majority of fruit and vegetables produced domestically are also consumed domestically. Domestic production is predominantly comprised of potatoes (58% of total fruit and vegetable production in 2020), mushrooms (13%), carrots and turnips (10%), cabbages and brassicas (5%), apples (3%) and soft fruits (1%) – primarily strawberries.[31] Field vegetable production is concentrated in Counties Dublin, Meath, Wexford and Cork, with approximately 200 commercial growers. The majority of domestic field vegetable production (75%) comes from the 50 largest Irish growers, in terms of area.[29] Relatively small proportions of Irish produce – particularly mushrooms, potatoes and apples – are exported.[31]

Imports of fresh produce comprise a mix of tropical fruits, field vegetables, apples and soft fruits.[31] Imported fruit and vegetables comes largely from other EU Member States, particularly the Netherlands (13% on average) and Spain (10% on average). A proportion is also imported from Great Britain (14%), although this has decreased following Brexit. Fruit and vegetables are imported to Ireland from over 200 territories globally, highlighting the complexity of the fresh produce supply chain.[31] Approximately a third (29%) of imported fruit and vegetables are types that can be produced domestically, including potatoes, apples, onions, carrots, tomatoes, cabbage, lettuce and soft fruits.[31, 99] The Department of Agriculture, Food and the Marine (DAFM) and Teagasc have noted that there are opportunities for Irish growers to increase domestic production and substitute a proportion of these imports.[29, 99, 98, 100]

Types of packaging used by producers at harvest stage depend on the type of fruit or vegetable in question. For example, at harvest stage; fruits such as kiwis, apples, pears and nectarines are typically loaded into reusable plastic bulk bins and/or wooden crates; while soft berries and lettuce are typically hand-packed into primary packaging at this early stage.[53, 101]

According to data from Bord Bia, organic produce accounts for 28.6% of vegetables and 15.0% of fruit sold in Ireland.[102]

The agri-food sector is highly regulated. In Ireland, the Department of Agriculture, Food and the Marine (DAFM) has the overall responsibility for regulating the sector. It is responsible for national implementation of the EU Common Agricultural Policy (CAP). It also has regulatory responsibilities in relation to the import of fresh fruit and vegetables into the State. The DAFM is the competent authority in Ireland for the regulation of the organic food sector. Its Organic Unit is responsible for ensuring compliance with the requirements for organic production and labelling of organic products, including organic fruit and vegetables, as set out in Regulation (EU) 2018/848.[87, 88]

Packaging Suppliers

Packaging suppliers provide packaging products, materials and equipment to various actors in the fresh produce supply chain, including producers, wholesalers, distributors and retailers. Packaging suppliers serving the Irish market include numerous suppliers of single-use packaging products, and (to a lesser degree) suppliers of reusable secondary and tertiary packaging. Reusable packaging represents a tiny proportion of all packaging placed on the market in Ireland – approximately 1% in 2021, according to data compiled by Repak.[39]

Wholesalers and Distributors

Food distributors and wholesalers act as intermediaries between producers and the consumer-facing retailers in the fruit and vegetable supply chain. Food distributors transport a manufacturer's products to market environments, for example, through sales to wholesalers or retailers. The distributor alleviates the pressures of temporarily storing products for producers and assists in the promotion and sale of products. Food wholesalers on the other hand represent an individual or company that buy products in bulk and sell them at profit to independent and private retailers. According to a study published in 2013, the types of packaging most commonly used in the transportation of fruit and vegetables in Europe are single-use wooden and cardboard boxes and reusable plastic crates.[54]

Retailers

Food retailers are businesses, including supermarkets, discount retailers, convenience stores, independent and premium grocery stores and farmers' markets, that sell food products, including fresh fruit and vegetables, to consumers. The food retail sector in Ireland is highly competitive. The larger supermarkets – Dunnes Stores (22.1%), SuperValu (part of the Musgrave Group) (22.0%) and Tesco (21.5%) – together with the discount retailers – Aldi (12.4%) and Lidl (12.8%) – have a combined market share of over 90%. [32] Large retailers proactively engage with and provide guidance to suppliers regarding packaging – with some retailers hosting supplier conferences/events – and may employ in-house packaging technologists.[103] Alternative food retailers and networks include cooperatives, country markets, farmers' markets and farm shops, which have a long tradition in Ireland.[104] Small retailers often operate with less purchasing power than larger competitors, in terms of financial investment and access to knowledge and technology, which impacts their ability to negotiate prices and may limit capacity to pursue packaging reduction initiatives.[105] A survey of householders conducted by VOICE found that over two thirds of items in the average recycling bin in Ireland originated from supermarkets.[106]

Consumers

Consumers represent the final stage in the supply chain of fresh fruit and vegetables for retail sale in Ireland.

A national consumer behavioural insights survey on 'Single use packaging for fruit and vegetables - usage and attitudes' was carried out in 2024 by Ipsos B&A on behalf of the EPA.[107] This indicates that 95% of people buy 'most' fresh fruit or vegetables from supermarkets. This correlates with Bord Bia research in 2020 which found that the majority of Irish consumers (93%) purchase fresh produce primarily from the large retailers. [108] Some key findings from the 2024 national consumer insights research include:

- Most people (61%) buy fresh fruit and vegetables at least once a week.
- 49% believe that supermarkets or grocery stores are the key decision makers regarding packaging (36% believe that distributor, wholesaler or importer are key decision makers, 8% believe primary producer or farmer group are key decision makers).
- Pre-packaged fruit and vegetables are more regularly used than loose options (53% purchase pre-packaged always or often). The majority of those who regularly buy pre-packaged fresh fruit and vegetables purchase pre-packaged predominantly.
- A majority (62%) would like stores to offer more loose fresh fruit and vegetables to reduce the amount of packaging they buy.
- Soft fruit and vegetables and those typically purchased in large quantities are preferred pre-packaged.
- 78% of people who purchase loose fruit and vegetables do so to reduce the packaging waste they bring home.

- 62% of people own a cloth reusable bag for carrying loose fruit and vegetables.
- The perceived advantages for pre-packaged fruit and vegetables are very different to those for loose produce. More transparent pricing, availability, food safety, and cleanness are the most common perceived advantages of pre-packaged options. Pro-environment reasons, quality, and flexibility with quantity are key factors in choosing loose fruit and vegetables.

Other research indicates that price and convenience (e.g., proximity of store) are key considerations for Irish consumers in purchasing fresh produce.[109] Although Irish consumers exhibit concern regarding the environmental impacts of packaging (particularly plastic), evidence of consumers opting for pre-packaged produce in spite of this awareness highlights a potential attitude-behaviour gap.[109] Research conducted under the EPA Research programme found that, on average, Irish consumers 'sometimes' or 'usually' opt to buy loose fruit and vegetables rather than pre-packaged items.[110] According to the 2020 Bord Bia survey, some Irish consumers increased their purchasing of packaged rather than loose produce in response to the Covid-19 pandemic.[108] Research has also found that Irish consumers tend to believe that food packaging is a bigger issue than food waste, which is consistent with research conducted elsewhere.[111, 112]

While the market for healthy food products is growing in Ireland, it is noted that Ireland's per capita consumption of fresh fruit and vegetables is far below the World Health Organisation (WHO) recommended intake of 400g per person per day and would need to increase substantially – by 40% in adults, 88% in adolescents and 80% in children – in order to meet this target.[31, 113]

Resource and Waste Management

Food waste and packaging waste are generated throughout the supply chain. Holders of waste have a general duty under waste management legislation, not to hold, transport, recover or dispose of waste in a manner that causes or is likely to cause environmental pollution. Resource and waste management actors are responsible for managing this waste. The waste industry in Ireland, comprised of a mix of small to large primarily private operators, offer services from waste collection to recovery and disposal operations.

Food Redistribution

Surplus food is also generated at various stages; for example, when produce is deemed un-saleable due to failure to meet quality criteria (e.g., too small or misshapen produce).[114] Surplus produce may be redistributed via food redistribution organisations such as FoodCloud or Too Good To Go, or diverted to lower value uses, such as animal feed.[115, 116, 117]

Other Actors

There are a number of additional actors involved in regulation and compliance related to the supply chain of fruit and vegetables for retail sale in Ireland and associated packaging. These include Repak and the Food Safety Authority of Ireland (FSAI).

Repak is a not-for-profit organisation that provides the Government-approved EPR scheme in Ireland. It supports its members, who are producers of packaging, to comply with their legal obligations under the Packaging Regulations. Repak members are charged fees, based on the weight and type of packaging placed on the market in Ireland. The structure of the fees promotes lightweighting of packaging and use of recyclable materials. Repak operates a voluntary Plastic Pledge, to promote packaging sustainability initiatives among its members (see below).

Case Study: Repak Plastic Pledge[118]

Repak members are invited to become signatories to its Plastic Pledge. Signatories commit to the four objectives of the Pledge:

1. To prioritise the prevention of plastic packaging waste by minimising avoidable single-use packaging and promoting packaging reuse, where possible;
2. To support Ireland to deliver the Circular Economy Package plastic recycling targets of 50% of all plastic packaging by 2025 and 55% by 2030, as set by the European Commission;
3. To simplify complexity within the plastic packaging supply chain by simplifying polymer usage and eliminating non-recyclable components in all plastic packaging by 2030; and
4. To help build a circular economy for used plastic packaging in Ireland and Europe by increasing the use of plastic packaging with a recycled content.

Signatories to the Plastic Pledge include Aldi, Lidl, Tesco, Musgrave Group, Total Produce, Fyffes and Meade Potato Co., among others. Plastic Pledge signatories can avail of Repak's 'Prevent & Save Programme', which provides guidance to members on packaging optimisation. The Pakman Awards, Repak's annual environmental awards, spotlight the efforts of the signatories.

Packaging reduction actions implemented by Plastic Pledge signatories in 2022 include lightweighting of plastic film bags for potatoes, carrots and salad leaves; and replacing plastic bags on bananas with recyclable bands. According to Repak's Plastic Pledge Report, actions of signatories between 2018 and 2022 resulted in the reduction or replacement of over 28,500 tonnes of plastic packaging.[103]

The FSAI is the national authority with responsibility for the coordination of food safety legislation in Ireland. It ensures the safety, integrity and authenticity of the food chain in Ireland by detecting, deterring and preventing breaches of food legislation and taking action to protect consumers in this regard. It is responsible for enforcing a wide range of food safety legislation, including regulations on the labelling of fresh fruit and vegetables and FCMs, including food packaging.

3.3.2 Stakeholder Insights

Additional considerations that arose during stakeholder engagement are as follows:

- Large retailers have influence on the specification and design of packaging used in the supply chain, linked to their purchasing power. Conversely, smaller retailers have less purchasing power, lack economies of scale, and may need larger retailers to create demand for packaging reduction options, such as loose produce.
- Large retailers have distribution centres, where fresh produce (and its packaging) is received from suppliers and prepared for the retail environment.
- Some retailers engage with and provide guidelines to their suppliers regarding packaging. This may include 'RAG' or 'traffic light' tables highlighting in red, amber and green the packaging materials and formats that are unacceptable, possibly acceptable (subject to approval), and broadly acceptable, respectively. These tables are informed by legislative requirements (e.g., banned materials/formats) and recyclability of the packaging waste at kerbside of the materials in question.
- Retailers may collaborate with third party consultants in relation to their packaging strategies,

guidelines and EPR compliance. These consultants could potentially play a role in the sharing of best practice and innovations in packaging reduction.

- The degree of influence that retailers have over packaging may vary depending on a range of factors. Retailers (and wholesalers/distributors) may have less influence over packaging of produce imported from outside of the EU that is packaged at source. Retailers may have greater control over the specification of 'own-brand' packaging rather than third-party packaging. Compared with other classes of food products, fresh fruit and vegetables tend to feature a relatively high proportion of 'own-brand' packaging, particularly among the larger retailers.

3.4 OPTIONS FOR REDUCING SINGLE-USE PACKAGING OF FRESH FRUIT AND VEGETABLES

3.4.1 Literature Review

Based on the literature review, key classes of potential options identified for reducing single-use packaging used in the supply chain of fresh fruit and vegetables are **dematerialisation**, **reusable packaging**, and **short food supply chains** (Figure 7). These options are discussed in the following sections.

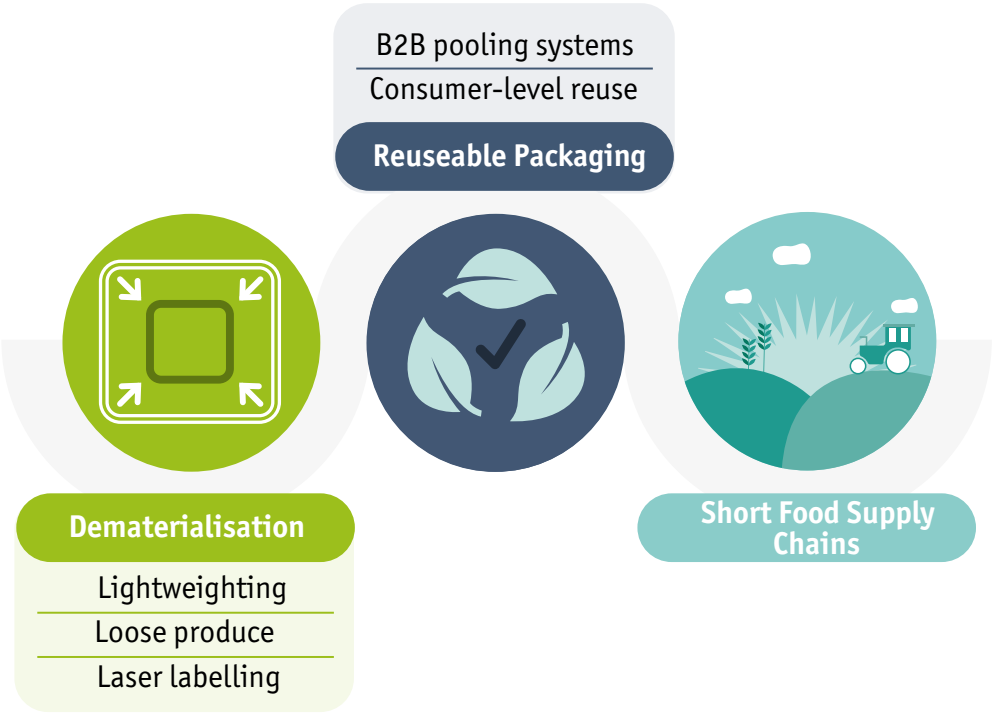

Figure 7: Options for reducing single-use packaging in the supply chain of fresh fruit and vegetables

Dematerialisation

Dematerialisation refers to *"The absolute or relative reduction in the quantity of materials used and/or the quantity of waste generated in the production of a unit of economic output"*.[8] In this instance, this refers to the absolute or relative reduction in the quantity of materials used in single-use packaging and includes options to reduce the materiality of packaging (e.g., through lightweighting) and eliminate packaging, where appropriate (e.g., by selling loose produce or through laser labelling).

Lightweighting

Lightweighting, the *"reduction of the overall amount of any material in a piece of packaging"*, is a well-established industry practice in packaging dematerialisation.[70, 119] It includes efforts to reduce the amount of material used in packaging through reducing thickness ('downgauging') and dimensions of packaging (e.g., by reducing void space or redundant parts).

Lightweighting presents an option for reducing single-use packaging where primary packaging cannot be fully eliminated, delivering potential benefits in terms reduced resource consumption in packaging manufacturing, emissions associated with transportation, and costs. However, a number of potential challenges associated with lightweighting have been identified, including loss of functionality of packaging (e.g., lesser protection of fresh produce), and challenges for packaging waste management and recyclability at end-of-life.[120]

Case Study: Top Seal Punnets

Stakeholder engagement indicates a trend in recent years of lightweighting fresh produce punnets by replacing hinged ('clamshell') or detachable lids with 'top seal', peelable, plastic films (Figure 8).[121] One report claims that the top seal film reduces plastic use by about 25% compared with the traditional clamshell lid, while having the added benefits of increasing shelf life and reducing the overall volume of the punnet, allowing a greater number to be packed into a single crate/box.[122] There are also examples of plastic top seal films being used with bio-based punnet trays.[123]

Figure 8: Top seal plastic berry punnet

Loose Produce

Depending on the nature of the produce and supply chain, in some instances, non-essential primary packaging may be entirely eliminated, with fruit and vegetables being sold loose to consumers. In addition to reducing packaging waste, this approach allows consumers to purchase exactly the amount needed, with potential positive impacts on household food waste.[94]

As discussed above, packaging can contribute to the prevention of food waste. However, research has also found that excessive use of primary packaging can be a driver of household food waste, by forcing consumers to purchase more than needed.[112, 124] Research undertaken by WRAP in 2022 has concluded that opportunities exist to reduce both food waste and plastic packaging.[124] WRAP has estimated that 21,500 tonnes of plastics could be avoided in the UK if a wider range of fresh produce sometimes sold loose were only sold loose in the future.[124]

This approach is potentially not suited to all types of fruit and vegetables. Research indicates, for example, that by preventing spoilage, plastic shrink wrapping of cucumbers is substantially preferable than loose/unpackaged from an environmental perspective, resulting in a net benefit in climate change impact.[125] Adoption of loose produce should be considered in the context of potential trade-offs (e.g., in relation to food waste and cross-contamination of microbes and allergens).[94] To support retailers in deciding whether to sell a particular fruit or vegetable loose, WRAP has published a decision tree addressing key considerations, including legislative requirements for pre-packaging, and sensitivity of produce to damage/spoilage, which is reproduced in **Appendix C**.[94]

The use of biodegradable, edible coatings to increase the shelf life of fruit and vegetables is an emerging area that could support packaging elimination in favour of loose produce. Studies have demonstrated the potential of edible biopolymers (including natural gums such as chitosan) to enhance the quality and shelf life of a wide range of fruit and vegetables.[126] Organisations developing edible coatings for fresh produce include Apeel, which has developed a plant-oil based coating, available in North America and Europe, that extends the shelf life of produce including cucumbers, citrus fruits, apples and avocadoes.[127] Since February 2022, Apeel has partnered with Asda in the UK to provide edible coatings on its avocadoes and citrus fruits.[128]

Efforts to switch to loose produce, where appropriate, may be supported by the implementation of new management practices in the retail environment to maintain the quality of the produce and prevent food waste, such as misting, 'topping off' and provision of home storage guidance alongside.[94, 129]

Case Study: Lidl Loose Produce

Lidl is part of the Schwarz group global retail group. Schwarz Group published its REset Plastic strategy in 2018 which sets out the group's commitment to reduce plastic packaging in its companies and raise awareness about the correct management of plastic waste.[130] Since its publication, the strategy has introduced various initiatives to reduce single use packaging used throughout its stores, including increased availability of loose fruit and vegetables.[130]

Lidl is in the process of reducing its plastic packaging across many of its product ranges, including fresh produce. Approximately 95% of the chain's own brand packaging is now recyclable, reusable, renewable or refillable, which illustrates a 29% decrease in plastic packaging in stores since 2017. Lidl recently eliminated black plastic packaging from fruit and vegetables, amongst other products, resulting in over 60 tonnes of black plastic waste being avoided by the supermarket chain each year.[131] The chain aims to achieve a 40% reduction in this area by 2025.[131]

Lidl is replacing its plastic packaging with loose alternatives, as appropriate. Currently, Lidl is working to increase the variety of loose fresh fruit and vegetables available in its stores. Approximately 20% of Lidl's fresh fruit and vegetables are sold loose. Lidl is further promoting its loose produce range by advertising reusable produce bags for sale alongside the loose produce. This affords consumers the opportunity to bring their recently purchased reusable Lidl produce bags, or their own reusable produce bags, to store for purchase of these products.[131]

Consumer behaviour in terms of purchasing fresh produce is considered a real barrier to the transition away from packaged produce. Lidl believes that through educational campaigns in store it can shift consumer perceptions of fresh produce to increase appreciation of value of fresh produce, reduce food waste and increase uptake of loose produce where available.

Case Study: Morrisons Loose Produce Areas, UK

Morrisons is the UK's 4th largest supermarket chain. Through the UK Plastics Pact, it has committed to reducing its own brand plastic packaging by 25% by 2025.[132] In 2018, Morrisons began a trial of loose produce areas in one of its stores in North Yorkshire. This involved increasing the number of fresh fruit and vegetable lines sold loose, changing merchandising, introducing chalkboard signage to create a market-like aesthetic, and replacing single-use plastic bags with paper equivalents. Customers could purchase produce loose or use the paper bags provided.[132]

Customers were interviewed to understand their reactions to the trial. They showed a preference for loose produce, highlighting the benefits of being able to purchase only the amount needed, including a potential reduction in household food waste.[132] Following the success of the trial, Morrisons rolled out this initiative out to 60 of its other stores. As a result, it observed an average increase of 40% in the number of customers purchasing loose produce. They estimated that this would result in the avoidance of over three tonnes of plastic packaging per week, equating to 156 tonnes a year.[132]

WRAP reported that, when Morrisons first introduced the loose produce trial, food waste in the store was 2.7 times higher than pre-trial. However, with the implementation of new management measures, it is reported that food waste returned to average levels within a few weeks.[132]

In 2019, 127 varieties of loose fruit and veg were on offer at Morrisons stores, including apples, pears, oranges, potatoes, onions, carrots, cauliflower, cabbages, chestnut mushrooms, figs and pomegranates. Research conducted by the British Growers Association found that Morrisons has the highest proportion of loose fresh produce of the major retailers in the UK, with 21% of its fresh produce being sold without any primary packaging.[133]

Case Study: French Ban on Single-use Plastic Packaging of Fruit and Vegetables

France's 'Anti-waste for a Circular Economy Law', adopted in February 2020, contains a range of provisions to support the transition to a circular economy in France.[134] The Law aims to phase out single-use plastic packaging by 2040, among other objectives. It provides for a number of bans on single-use plastic items, including tea bags, disposable tableware, and packaging of fresh fruit and vegetables.[135, 136]

The Law prohibits the sale of fresh, unprocessed fruit and vegetables weighing less than 1.5 kg in packaging made wholly or partly of plastic, thereby promoting the sale of loose produce. The ban came into effect on 1 July 2023, with a transition period until 31 December 2023, during which existing inventories could be drawn down.

French legislation provides a list of 29 fruit and vegetables *"at risk of spoilage when sold loose"* that are currently exempted from the ban, including numerous types of berries and salad leaves, sprouted beans and seeds, endive, asparagus, broccoli, mushrooms, early potatoes, early and baby carrots, aromatic herbs, and fruit sold fully ripe. A previously proposed list of exempted produce was contested by industry stakeholders and ultimately overturned by the French Council of State.[137] A subsequent decree, published in June 2023 provided a revised (extended) list, and an exemption for the use of rubber bands to bundle smaller items, such as herbs and radishes.[138, 139]

Some operators in the sector have expressed concerns regarding the costs of implementing the French ban and distortion of competition associated with the lack of a harmonised approach across the EU Member States.[140, 141] If adopted, the proposed PPWR, which includes a similar ban on the use of single-use plastic packaging for unprocessed fresh fruit and vegetables under 1.5kg, would provide a consistent approach across the Member States from 2030.

The French Law also bans the use of sticky labels on fruit and vegetables after 1 January 2022, except where these are home compostable and made partly or wholly of bio-based materials.

The Law also addresses the bulk sale of food products more broadly. It provides a definition of bulk sale: *"the sale to the consumer of products presented without packaging, in quantities chosen by the consumer, in reusable or reusable containers"* […] *"offered through self-service or assisted service at mobile sales outlets"*. It allows that all common consumer products may be sold in bulk, unless where public health reasons warrant otherwise. It empowers consumers to be served in their own containers and makes consumers responsible for the hygiene of their own containers. It also requires that retail businesses with a sales area greater than 400 m^2 must provide reusable containers (replacing single-use packaging) for purchasing bulk products.[134, 142]

Laser Labelling

Laser labelling presents an option to eliminate single-use sticky labels or other forms of single-use packaging of fresh fruit and vegetables used for provision of information. The technology involves marking fruit and vegetables with a machine that uses CO_2 laser technology to change the pigment in the outer layer of skin without affecting the qualities or shelf-life of the produce.[143, 144] This option has been implemented by a number of large retailers, including ICA in Sweden, M&S and Tesco in the UK and Carrefour in Belgium.[143, 145, 146, 147, 148]

Laser labelling has been noted as a particularly useful approach for produce that tends to shed sticky labels (like melons and coconuts), and ICA has noted that it may reduce the use of pre-packaging to prevent commingling/substitution of organic and non-organic produce.[145, 146] However, it is noted that the upfront investment of the laser labelling machine is high, the approach is not suitable for all types of fruit and vegetables, and there may be poor consumer acceptance of laser labelling on produce with edible skin.[149, 150]

Case Study: ICA, Sweden – Laser Labels for Organic Fruit and Vegetables

In 2016, Swedish supermarket chain, ICA, became the first retailer in Sweden to introduce laser labels for fruit and vegetables.[145, 146] Initially, the technology was piloted on organic avocadoes and sweet potatoes. Following a positive consumer response, in 2017 the approach was adopted as a permanent practice for sweet potatoes (but discontinued for avocados, for which the laser labelling didn't perform as well as expected), and expanded to other organic produce, including melons and butternut squash.[151] The laser labelling is carried out for ICA by its suppliers at packing houses in the Netherlands and Spain. ICA's laser labels identify the item's country of origin, PLU code and organic status.[151] To implement this initiative, ICA collaborated with a number of partners, including its Dutch and Spanish produce suppliers, and the Spanish company behind the laser technology, Laser Food.[143, 145, 146]

Reusable Packaging

Reusable packaging refers to *"Packaging which has been conceived, designed and placed on the market to accomplish within its lifecycle multiple trips or rotations by being refilled or reused for the same purpose for which it was conceived"*.[1] Reusable packaging may be used as an alternative to single-use packaging at various stages in the fruit and vegetable supply chain. Key reusable packaging options identified are B2B crate and pallet pooling systems and consumer level reuse, as described below.

B2B Pooling Systems

The reusable packaging pooling system is an approach to avoiding single-use packaging and realising supply chain efficiencies. It refers to a class of B2B, product-as-a-service (PaaS) model, whereby a third party (the pooler) provides ready-to-use reusable packaging (typically durable plastic crates and pallets) to actors in the supply chain (particularly producers). It maintains ownership and responsibility for the packaging throughout the lifecycle. The packaging is used to convey produce throughout the supply chain, from producer to retailer. Through reverse logistics, the packaging is returned to the pooler, who carries out checks, cleaning (washing) and repairs, where needed, before cycling the packaging back into the system.[152, 153] Figure 9, below, provides an overview of the B2B pooling system process.

This closed-loop system provides an alternative to single-use or short-lived secondary and tertiary packaging, such as cardboard and wooden boxes. It also provides an alternative to individual organisations in the supply chain owning and maintaining their own pool of reusable crates or pallets.

Benefits of this approach may include reduced consumption of virgin materials and mitigation of the environmental impacts of the packaging sector.[154] Pooling enterprises have also noted that this type of system can provide greater protection to produce, by providing more robust packaging and reducing the need for double-handling, and can reduce costs for supply chain actors associated with procurement of packaging and labour costs associated with unpacking in the retail environment.[153, 155]

LCAs undertaken to compare the lifecycle impacts of reusable plastic packaging with single-use equivalents have yielded differing results. Some assessments have concluded that reusable packaging is less environmentally impactful than single-use equivalents, such as cardboard or wooden boxes, while others have found the opposite.[156, 157, 158, 154] Research conducted by Zero Waste Europe, the University of Utrecht and Reloop based on results of LCAs has concluded that, overall, reusable packaging provides a more environmentally sustainable alternative to single-use equivalents.[21] Research undertaken by the EC's Joint Research Centre (JRC) highlights the challenges in comparing results of different assessments of the lifecycle impacts of reusable and single-use packaging alternatives due to a high degree of variability in the methodologies, assumptions and data used.[159] This emphasises the need for a robust, evidence-based approach when considering the relative merit of reusable and single-use secondary/tertiary packaging in different scenarios. It also underlines the need for a harmonised, best practice approach to LCA of reusable and single-use packaging equivalents.

Research also highlights potential food safety problems associated with reusable crates, which can act as a source of microbial cross-contamination, if improperly managed.[160, 161] There are also potential food safety risks associated with the release of hazardous substances from reusable plastic packaging due to incorporation of recycled plastics and/or material degradation from repeated use.[162, 163, 164]

There are numerous examples of reusable packaging pooling systems serving fruit and vegetable supply chains in the EU, including IFCO, Euro Pool Group's LPR and Euro Pool System solutions for reusable pallets and trays respectively, and the Swedish Return System (see case study, below).[155, 165, 166] The adoption of reusable packaging pooling systems in the fruit and vegetable supply chain in Ireland is varied and fragmented, although enterprises such as Glan Arís (see case study, below) and Tosca are providing B2B pooling services for the Irish food sector.

Case Study: Swedish Return System (Svenska Retursystem, n.d.)

The Swedish Return System ('Svenska Retursystem') (SRS) was established in 1997 by the Trade Association for Grocery of Sweden and the Swedish Food and Drinks Retailers Association, using start-up funding from EU LIFE.[167, 168] It currently has over 1,500 customers and covers the supply chain of over half of all fresh produce in Sweden.[167] The mission of SRS is to make the Swedish food industry's supply chain as efficient and sustainable as possible, by substituting single-use with reusable packaging.

The SRS provides a standardised reusable container pooling system for various stakeholders in the Swedish food industry as a paid service. A cycle in the system begins when SRS delivers reusable containers (plastic crates and whole and half-pallets) to producers in Sweden or elsewhere in Europe. Producers fill the containers with fresh produce. A rough patch on each crate allows the attachment of stickers. Whole pallets have integrated RFID tags to provide traceability. Wholesalers distribute orders to retailers, who can use the SRS containers directly in shelf displays, avoiding the need to unpack crates. According to SRS, a medium-sized retail store saves approx. 160 working hours per year using its system. Retailers return empty containers to wholesalers, who in turn return them to SRS logistics facilities, where crates and pallets are washed, checked and repaired, as needed, before being cycled back into the system. There are some variations of this system for certain classes of container. For example, whole pallets aren't washed after every use, and can be transferred directly from wholesalers to producers.

Customers of SRS use a dedicated website, Smart Pooling, to order the containers they need. Fees and unit deposits are charged at the same rates for all users, regardless of size or location within Sweden. The unit deposit is around €4 per crate and €18 per half-pallet. Relative to alternative systems with disposable packaging, the SRS results in cost savings of about 25% for users.

SRS's reusable containers are made of durable, recyclable plastic, and manufactured by Schoeller Allibert, Schoeller Arca Systems, IP-Group and/or Shuert Technologies.[168] Containers come in a range of sizes and are designed to be standardised, safe and easy to handle, and to minimise food spoilage. They are typically used 100 – 150 times and have an average lifespan of 15 years. End-of-life containers are recycled into new containers or other products. SRS has also developed a bespoke pallet of 100% recycled plastic for Systembolaget, the Government-owned network of off-licences in Sweden.

According to results of validated, third-party LCA, using SRS's reusable crates and pallets results in significant emission reductions relative to disposable packaging alternatives. The reusable crate is reported to result in 78% lower CO_2 emissions compared with a single-use alternative; while the reusable plastic pallet is reported to result in a reduction of 10-61% relative to a wooden pallet, depending on the LCA method used. According to SRS, in 2022, the Swedish food industry avoided over 36,400 tonnes of CO_2 emissions using its pooling system.

In its own operations in Sweden, SRS has committed to being fossil-free by 2025. Efforts to achieve this target include switching transport to trains, where possible; using shortest possible delivery routes; and using fossil-free fuels in transportation. The greatest share of SRS' energy consumption is used to heat water for its washing system. To mitigate the impacts of this, SRS recycles hot water, where possible; and is adding large-scale solar photovoltaic arrays to the rooftops of its facilities to generate renewable energy.

Case Study: Swedish Return System (Svenska Retursystem, n.d.)

According to the Ellen MacArthur Foundation, the success of the SRS may be attributed to its use of industry-wide collaboration and the standardised design of its reusable containers.[167]

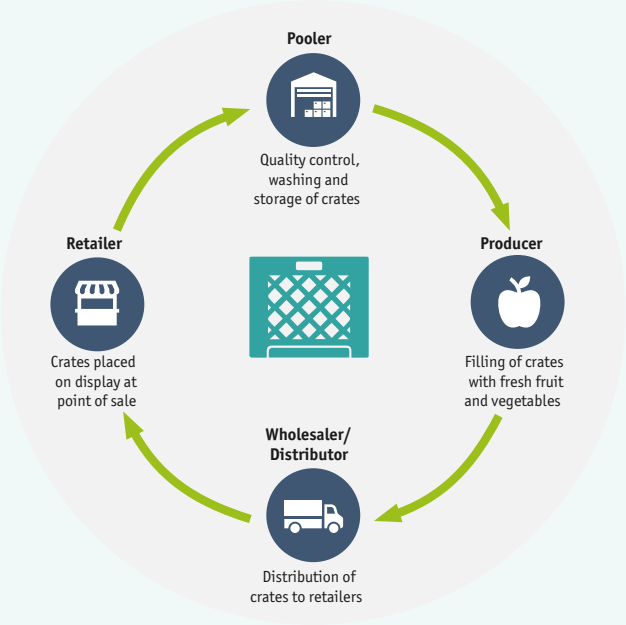

Figure 9: B2B reusable crate pooling system – overview

Case Study: Glan Arís

Glan Arís is an Irish business (a subsidiary of the Donnelly Group), established in 2002, providing a B2B reusable crate and pallet pooling service to the Irish grocery sector.[169, 170] It also provides a management and washing service to retailers who have invested in their own pool of crates.[171]

Between its two facilities near Dublin Airport and at Little Island in Co. Cork, Glan Arís has equipment and personnel providing for the inspection, washing, drying, repair and storage of a range of reusable packaging formats, including crates and plastic pallets.[169, 171] Its fully- and semi-automated washing machines are capable of cleaning reusable containers in line with the applicable food safety requirements.[171] It recycles water and utilises heat recovery in its washing systems and uses renewable energy to power its operations.[47, 171, 172] According to its website, Glan Arís handles over 10 million reusable packaging trips each years, and has the capacity to scale up.[171] Like the SRS, Glan Arís sources its pool of reusable crates and pallets from manufacturer Schoeller Allibert.[173]

Glan Arís's customers include Keogh's Farms, who have noted the benefits of the reusable crates over single-use cardboard boxes in terms of the additional protection provided of the produce, and time and cost savings.[174] Glan Arís's customer are responsible for collecting and delivering reusable packaging from/to its facilities – this differs from the SRS case, in which the pooler undertakes the initial delivery to producers.[47]

Consumer-level Reuse

Reuse is also an option at the point of sale where consumers can use their own reusable packaging to purchase loose produce. This approach is better established in the sale of bulk dry/ambient foods (such as grains, pulses, beans and nuts), toiletries and cleaning products, which are inherently more stable and less perishable than fresh produce; as evidenced by the proliferation of zero-waste shops and innovative refill pilots at large retailers.[175, 176, 177] This approach is complementary to loose produce, as described above, in that it allows consumers to use their own reusable packaging (e.g., textile bags) rather than using single-use plastic or paper bags provided by the retailer. As highlighted in Section 3.3, consumer research indicates that 62% of Irish people own a cloth reusable bag for carrying fresh produce. Consumer-level reusable packaging may also be sold alongside fresh produce, as is the case at Lidl and Tesco stores in Ireland.[178, 179]

Short Food Supply Chains

It has been noted that longer supply chains may increase the need for food packaging to prevent spoilage or deterioration of produce travelling long distances from farms to consumers.[38] Short food supply chains (SFSCs), therefore, constitute a potential option to reduce the need for single-use packaging of fruit and vegetables, while offering a range of co-benefits, including reducing greenhouse gas emissions associated with international transportation and cold-chain, reducing food waste, supporting local economies, fairer prices for farmers and consumers, local social cohesion and job creation, and increasing resilience in the context of disruptions to global supply chains.[38, 180, 181, 182, 183, 184, 185, 186]

It should be noted, however, that primary research comparing the quantum of packaging in SFSC and longer supply chains was hard to identify. One study was identified comparing packaging waste generation for apples and carrots distributed via a local 'veg box' scheme compared with traditional large-scale retail trade, which concluded that the veg box scheme could not be considered a packaging waste prevention measure.[187]

The EC funded agroBRIDGES project, of which Teagasc was a partner, found that access and affordability were identified as key challenges for European consumers in purchasing food from SFSCs.[188] There are a range of potential models for the realisation of SFSCs. These include on-farm sales models such as farm shops and 'pick-your-own produce' farms, which require relatively a lot of time and effort on the part of the consumer; as well as more accessible options, including farmers' markets; local food shops; local/regional food lines in supermarkets; food cooperatives and solidarity-based purchasing groups; community supported agriculture (CSA) schemes; and veg box schemes, which may involve home delivery or centralised collection points.[180, 182, 183]

There are various initiatives that support SFSC models, including food hubs, online ordering platforms, farmers' market networks, and labelling schemes for local/regional foods.[182, 183, 188] 'Food hubs' refers to an emerging organisational model that aims to facilitate the interaction between producers and consumers in SFSC, through the aggregation, distribution and marketing of local and regional produce.[183] Both food hubs and online ordering platforms serve as an intermediary connecting producers and consumers, fulfilling a similar role to that of the wholesaler.

Case Study: Cambridge Food Hub

The Cambridge Food Hub in the UK aims "*To significantly increase the amount of locally and sustainably produced food that is consumed in Cambridge using processes and facilities that are as environmentally sustainable as possible and with an ethical business model that aims to provide value to its customers, suppliers, employees, owners, the local community and the environment in equal measure.*"[189] It supports local producers (primarily in Cambridgeshire and the neighbouring counties of Suffolk and Norfolk) in selling their produce by facilitating access to new markets and stockists and providing free storage and distribution of stock.[190, 191] It acts as an intermediary between producers and customers, including independent retailers and catering businesses, via the food hub's shopfront on Open Food Network, an online ordering platform for local food producers.[191] It does not negotiate on price, allowing producers to sell at the price that suits them.[190] It promotes zero-waste retail, and supports producers who commit to sustainable packaging, such as reusable formats.[190] It uses reusable plastic crates and pallets in its supply chain.[192] On its website, it notes that short supply chains can help make reusable packaging systems viable, by reducing transport distances and the number of actors involved and ensuring high rates of return.[192]

Opportunity – The Role of Digitalisation in Single-use Packaging Reduction

There are opportunities to leverage digital technology to support or complement single-use packaging reduction initiatives. These include electronic shelf labels for retail stores and the use of radio frequency identification technology in reusable packaging systems.

Electronic shelf labels (ESLs) could be used in conjunction with loose produce to provide information that is useful to consumers at the point of sale (e.g., pricing, origin, variety, organic status, etc.) and retail workers (e.g., inventory data). Additionally, ESLs can tie into efforts to reduce food waste, by advertising markdowns on surplus products or products nearing expiration.[193, 194]

Radio frequency identification (RFID) refers to a wireless system that uses radio waves to transfer data. RFID systems are comprised of readers and tags. RFID tags can store information, ranging from a single serial number to several pages of data. RFID tags may be passive (lacking a battery and powered by the reader) or active (powered by a battery).[195]

RFID technology is a useful tool in supply chain management, which can be applied on its own or in combination with other technologies to provide accurate, real-time information regarding inventory, traceability and freshness of produce.[196, 197, 198] Packaging may have RFID tags affixed, which are scanned using a reader, providing information and traceability throughout the supply chain in an efficient manner.[199] RFID readers may be mobile (e.g., handheld) or fixed (e.g., a RFID 'gate' that automatically scans incoming pallets at a warehouse).[199]

RFID technology can be used as a complementary measure to optimise reusable packaging systems, particularly where tags are designed to withstand multiple cycles of use.[200] RFID technology is being applied to provide traceability of reusable pallets and crates, including in reusable pooling systems for fresh produce supply chains.[166, 201, 202] The potential of RFID technology to prevent food waste through optimised supply chain management and monitoring of produce has been highlighted.[203]

However, 'smart packaging' is not necessarily circular packaging. Use of RFID technology could also exacerbate packaging waste problems; for example, where RFID tags (which contain chips and a variety of materials, including metals and adhesives) are integrated into single-use packaging, with negative implications for recyclability of single-use packaging and generation of uncontrolled WEEE.[203, 204, 205]

3.4.2 Stakeholder Insights

Survey respondents were asked to identify, in their view, the most promising options for reducing single-use packaging in the supply chain of fruit and vegetables. Options identified included reusable alternatives (including reusable crates and pallets, and consumer-level reuse), lightweighting, loose produce and use of edible coatings to prolong shelf-life of same. A number of respondents referred to material substitution using recycled, recyclable, compostable or biodegradable alternatives, highlighting some potential confusion regarding the concept of single-use packaging. A number of stakeholders called for legislation (e.g., to limit the use of single-use packaging in certain formats or applications).

Survey respondents were asked to rank in order of importance a number of potential challenges associated with reducing single-use packaging used in the supply chain of fruit and vegetables for retail sale in Ireland. The aggregated ranking (Figure 10) shows that food waste was identified as the primary challenge, followed by economic viability, consumer perceptions, food safety/hygiene, technical readiness, inconvenience for consumers and regulatory barriers.

Survey respondents were asked to identify any additional challenges not provided in the list. Additional challenges identified included competition between retailers resulting from non-uniform adoption, established norms and behaviours (e.g., among consumers and retail workers), and the lack of existing infrastructure to support systems of reuse (e.g., washing facilities capable of meeting food safety requirements at scale).

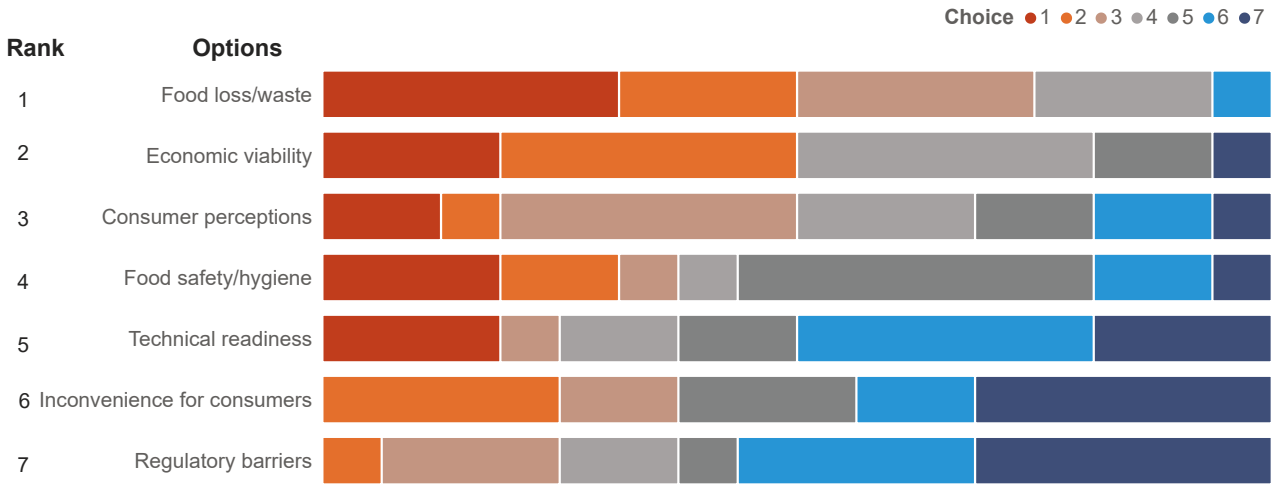

Figure 10: Survey responses: Rank in order of importance: Of the following, in your view, what are the most significant challenges associated with reducing single-use packaging used in the supply chain of fruit and vegetables for retail sale in Ireland?

Additional considerations that arose during stakeholder engagement are summarised in the following sections:

Dematerialisation

Lightweighting

- Lightweighting is a well-established approach to reducing single-use packaging.
- Strategies that have been implemented include reducing gauges (i.e., thickness) of plastic films, removing bubble padding from berry punnets, replacing lids with top seal films, and replacing single-use bags with adhesive bands on bunches of bananas. Even 'hand wrap' used to secure pallets in transit has reduced in thickness in recent years.
- For industry actors, lightweighting makes sense from an economic perspective, by reducing the cost of packaging and the magnitude of the weight-based EPR fees.
- Potential opportunities to support further lightweighting may include the use of technologies like QR codes to reduce the area of packaging needed for provision of information, providing guidance for producers and specifiers on packaging optimisation, and ensuring manufacturers have detailed information about minimum requirements of packaging and conditions in the supply chain to avoid overspecification. Assessments (e.g., strength testing) can also be applied to ensure that lighter packaging products are fit-for-purpose.
- Lightweighting may not always result in a more sustainable or functional packaging product overall. For example, when packaging materials become very light, their qualities change and they may begin to lose their functionality. Additionally, lightweighting may promote the use of plastics over alternative materials. Furthermore, lighter packaging may be less recyclable and more prone to 'leakage' from recycling systems.

Loose Produce

- There are potential opportunities to increase the proportion of fresh fruit and vegetables sold loose in Ireland, although a number of potential challenges exist.
- There is a need for an evidence-based approach, considering potential impacts of switching to loose produce in terms of food waste.
- Opportunities to remove primary packaging in favour of loose produce should be considered on a case-by-case basis. While there are certain types of fruit and vegetables that may not be suitable for loose sale due to high levels of perishability and fragility (e.g., berries, salad leaves, herbs and cucumbers); there are types of fruit and vegetables that do not necessarily need primary packaging for food waste prevention. Where primary packaging is used for other purposes (e.g., to create a multipack/sales unit), there are opportunities to switch to loose.
- Legislation or guidelines could be used to identify evidence-based lists of fresh fruit and vegetables that are suitable (and unsuitable) for loose sale, based on perishability and fragility. This could start with an initial list of 10 items for which loose sale has demonstrated feasibility.
- Some retailers are already providing loose produce in Ireland. While wholesalers and distributors could potentially provide more lines of produce in a loose format, demand may be limited from retailers for a number of reasons.
- A key potential challenge is that there may currently be little to no price advantage for retailers to switch to loose produce. Switching to loose produce could result in negative economic impacts for supply chain actors (including retailers), resulting from (i) consumers purchasing less (because they are facilitated to purchase only what they need), and/or (ii) potentially switching to retailers who offer pre-packaged alternatives as a matter of preference. Some retailers may be providing the same lines of produce both in loose and pre-packaged formats, to ensure consumers have a choice. There is a potential risk that if loose produce is adopted non-uniformly among retailers, that a cohort of consumers will simply switch to the pre-packaged alternatives, where they exist, and that loose produce lines may be discontinued where there is no commercial advantage.
- When fruit and vegetables are sold loose, consumers have the opportunity to reject or 'grade out' less desirable items (e.g., 'wonky veg'), whereas with multipacks, consumers have less freedom in this regard. This may potentially increase the amount of surplus and food waste occurring in the retail environment. There are a number of potential approaches to dealing with this problem, including discounted sale (e.g., 'waste not' boxes) and partnerships with food redistribution organisations (e.g., FoodCloud) and apps (e.g., Too Good to Go).
- There may be an attitude-behaviour gap among consumers, whereby consumers opt for pre-packaged over loose produce despite concerns regarding the environmental impacts single-use packaging. There are a number of potential reasons for this behaviour, including convenience (packaged produce being quicker to pick up and scan at tills) and negative perceptions regarding the hygiene and quality of loose produce. To promote consumer acceptance of loose produce, there may be a need for education to foster an awareness that loose produce is clean and safe, and to discourage rejection of less aesthetically appealing (or 'wonky') items.
- Switching to loose produce presents a number of potential challenges at the till. Because loose produce does not have a PLU code or barcode, retail workers and consumers may have difficulties identifying and scanning items at the till, particularly where self-service tills are concerned. Loose produce also increases the risk of deliberate or accidental substitution (e.g., where a consumer pays for a less expensive item than what is taken).
- Adoption of loose organic produce presents potential challenges. The use of primary packaging of organic produce to prevent commingling and substitution is an established practice among retailers, although not strictly required. Retailers may be reluctant to sell organic produce due

to increased risk of commingling/substitution and associated potential economic impacts and/or non-compliance with organic standards. In other Member States (such as France and Germany), alternative measures may be more widely used, such as using different varieties or colours where the same types of organic and non-organic fruit and vegetables are sold loose in the same store. Retailers may benefit from assurance that using such alternative measures would be accepted during organic inspections.

- There is a potential risk that loose produce might be adopted in a misleading manner, in which primary packaging is removed (e.g., at packing houses or distribution centres) to present produce in a loose format at the point of sale. If this practice were adopted, there is a risk that the net quantity of single-use packaging used in the supply chain could actually increase (e.g., if consumers subsequently re-pack produce in single-use bags). However, the likelihood of this practice may be low, given the labour costs associated with unpacking individual sales units.
- Requirements regarding the pricing of produce could potentially negatively affect consumer perceptions of the price of loose produce. Where products are sold loose by weight/in bulk, only the unit price (i.e., price/kg) may be displayed.[206] This may result in the price of loose produce appearing high to consumers compared to the price per pack of equivalent pre-packaged produce.

Laser Labelling

- Laser labelling is yet to be adopted in Ireland, although there has been some research and trials on the technology.
- The upfront capital costs associated with laser labelling could be high, although the technology may be becoming more commercially viable.
- The technology may have limited applicability as an alternative to sticky labels or other single-use packaging used for the provision of information, as it may not be suitable for all types of fruit and vegetables.
- If laser labels were to be introduced in Ireland, the proper procedures would need to be followed to ensure compliance with food labelling and food safety requirements.
- The requirement under the proposed PPWR for sticky labels to be compostable within three years of entry into force could potentially undermine investment in laser labelling.

Reusable Packaging

B2B Pooling Systems

- The current system of use of secondary and tertiary packaging in the supply chain of fresh fruit and vegetables in Ireland is varied and somewhat fragmented. A number of retailers are using their own reusable containers, as are some sellers at farmers' markets, while other retailers rely to a greater degree on single-use cardboard and/or wooden boxes.
- Potential benefits of the adoption of this approach include efficiencies associated with standardised, stackable and collapsible reusable containers, and reduced double-handling and labour costs associated with unpacking boxes (as crates can be used directly in shelf displays).
- Slots could be provided on crates for information cards (as is the case with some crates currently on the market), avoiding the need for sticky labels and/or individual labelling. Colour-coded labels or crates could be used to easily distinguish produce (e.g., organic and non-organic). There is also an opportunity to combine reusable containers with RFID technology linked to software/apps, providing for the sharing of information via digital platforms.
- Implementing a B2B reusable container pooling system for the fruit and vegetable supply chain in Ireland would be a complex undertaking requiring multi-stakeholder collaboration to identify a solution that works well for all actors.

- A B2B pooling system would need to ensure a consistent supply of clean crates during busy periods and provide confidence that robust procedures are in place to mitigate food safety risks associated with potential cross-contamination with microbes and allergens, and use of recycled plastics. The washing process would need to ensure food safety while minimising environmental impacts associated with energy and water use.
- There is a need to adopt an evidence-based approach in considering the relative merit of reusable versus single-use secondary and tertiary packaging, given that LCAs in this area have yielded mixed results.
- The benefits of reusable crates may be less evident over longer distances, due to environmental impacts associated with increased weights and transportation.
- A B2B pooling system may be easier to implement domestically with SFSC. Reusable containers are valuable assets, susceptible to theft, and harder to control with international trade.
- Standardisation of reusable packaging can be beneficial in terms of efficient stacking, transportation and storage. However, standardisation may also be problematic in that different fruit and vegetables have different packaging requirements. In some instances, standardisation may result in overspecification.

Consumer-level Reuse

- A number of retailers in Ireland are implementing measures to support consumer-level reuse, including the provision of reusable bags (for purchase) at the point of sale of loose fresh fruit and vegetables. To encourage consumers to switch to the reusable bags, retailers may reduce the availability of single-use plastic bags in tandem with the introduction of reusable alternatives.
- It may be difficult to quantify the number of times that consumers reuse reusable bags. There is a risk that a reusable bag/container may have a greater lifecycle impact than a single-use equivalent if it is not reused a sufficient number of times.
- Consumer-level reuse requires additional time and effort on the part of consumers, who need to remember to bring their own bags/containers with them when shopping.
- The approach also poses some potential (although minor) challenges at the point of sale (e.g., if the weight of the bag is not known or accounted for when weighing produce at tills). Provision of weighing scales in loose produce areas could help address this issue while supporting consumers to purchase precisely the amount needed.

Short Food Supply Chains

- It is unclear whether the use of SFSC would result in a net reduction in single-use packaging relative to longer supply chains.
- In order to support SFSC, local, in-season produce should be encouraged, and greater support given to farmers' markets, which currently account for a relatively small proportion of fresh produce sold.
- The use of SFSC may be complementary to B2B pooling systems, which may be more viable and sustainable at the national/regional scale.
- Increasing the proportion of produce from SFSC could deliver cost savings to retailers, by eliminating steps and costs in the supply chain.
- Increasing requirements for retailers to report on social impacts in the supply chain (e.g., under the proposed Directive on corporate sustainability due diligence)[207] may have an impact on consumers' willingness to purchase imported produce.

- The feasibility of increasing the proportion of fresh fruit and vegetables sourced from SFSC may be constrained, given that the majority produced domestically is also consumed domestically, with very limited exports. A greater supply of Irish fruit and vegetables would be needed in order to scale the proportion of SFSC.
- Irish produce may not necessarily always be the most sustainable option, particularly where a type of fruit or vegetable is out of season in Ireland, highlighting the importance of considering seasonality as well as distance travelled.

3.4.3 Summary

Table 3, below, provides a consolidation of insights gathered in relation to each single-use packaging reduction option during the literature review and stakeholder engagement. Key benefits and opportunities, challenges and other considerations are highlighted in each case.

Table 3: Single-use packaging reduction options – overview

Option	Benefits & Opportunities	Challenges	Other Considerations
Dematerialisation			

Lightweighting	• Reduces resource intensity of packaging where it cannot be removed
	• May be supported by:
	  ▸ Measures to reduce space needed for text on packaging (e.g., QR codes)
	  ▸ Design guidelines for producers, specifiers
	  ▸ Providing detailed information to designers
		• Lightest packaging not necessarily the most sustainable or functional packaging
		• Downgauging may reduce functionality of materials and recyclability
		• Lighter packaging may be more prone to 'leakage' from waste management systems
		• May promote use of plastics over other materials
			• Well established practice, driven by cost reductions and weight-based EPR fees

Loose produce	• Reduces primary packaging
	• Already implemented and opportunities exist to scale
	• Allows consumers to purchase exact amount needed – potential positive impact on food waste
	• May be supported by:
	  ▸ Legislation/guidelines identifying suitable/ unsuitable fruit and vegetables
	  ▸ Decision tree for loose produce
	  ▸ Measures to reduce food waste in retail environment (e.g., 'waste not' boxes, partnerships with food redistribution organisations)
	  ▸ Consumer education to support acceptance
		• Not suited to all fruit and vegetables (e.g., berries)
		• Perceived consumer preference for pre-packaged produce – convenience, hygiene, quality, price
		• Potential negative economic impact resulting from consumers purchasing less
		• Potential negative economic impact resulting from consumers switching to alternative retailers
		• Consumers can grade out 'wonky' fruit and veg – potential increase in food waste in retail environment
		• Challenges at till – no PLU code, risk of substitution
		• Potential risk of primary packaging being removed by retailers to display produce as 'loose' – no reduction in packaging
		• Organic produce – retailers may have concerns regarding increased risk of commingling and substitution – alternative measures needed
			• Needs to be considered in context of potential trade-offs (e.g., with food waste, cross-contamination)

Option	Benefits & Opportunities	Challenges	Other Considerations
Laser labelling	• Reduces primary packaging • Particularly useful for produce that shed stickers • Potential application in organic produce, avoiding need for primary packaging to prevent commingling and substitution	• Potentially not suitable for all fruit and vegetables that typically have sticky labels (e.g., citrus) • May not be accepted by consumers on produce with edible skin • At early stage of adoption – not implemented in Ireland although adopted by some retailers in Europe • Upfront capital costs of machinery may be high – but may be becoming more economically viable	• If implemented in Ireland, would need to ensure compliance with food safety and labelling requirements
Reusable packaging			
B2B pooling systems	• Reduces secondary/tertiary packaging • More robust secondary/tertiary packaging • Reduced packing/unpacking – saves time, costs and avoids double-handling • Well established, successful elsewhere (e.g., Sweden) • Current system in Ireland is varied and fragmented – introduction of a harmonised pooling system potentially offers significant efficiencies • Can be combined with RFID technology for enhanced traceability • Standardised, stackable, collapsible crates • Complementary to loose produce – reusable crates can be used in retail shelf displays	• Significant upfront investment needed in R&D and infrastructure • May be less well suited to international imports – potentially greater risk of loss/theft, transport emissions due to increased weight • Standardisation may be problematic in some instances – different fruit and vegetables have different packaging requirements; risk of overspecification • Potentially increased risk of cross-contamination due to reuse – need to ensure washing systems are effective • LCAs have yielded mixed results – careful consideration of relative merit and lifecycle impacts required	• Multi-stakeholder engagement and collaboration needed to develop an optimal model for Ireland

Option	Benefits & Opportunities	Challenges	Other Considerations
Consumer-level reuse	• Reduces primary packaging • Complementary to loose produce • Adopted by a number of retailers in Ireland	• Risk of greater overall lifecycle impact if reusable bag/ container not reused sufficient number of times • Requires additional time, planning and effort on the part of consumers • Potential challenges at till – weight of reusable bag/ container unknown or not accounted for	
Short food supply chains			

Short food supply chains	• May be complementary to B2B pooling systems – potentially more viable at national scale
	• Numerous potential co-benefits
	• May be supported by:
	  ▸ Promoting local, seasonal produce
	  ▸ Measures to support farmers' markets, food co-ops, community supported agriculture (CSA), etc.
	  ▸ Food hubs
	  ▸ Online ordering platforms
	  ▸ Farmers' market networks
	  ▸ Labelling schemes for Irish/regional produce
	  ▸ Irish/regional produce lines in large retailers
		• Unknown whether SFSC actually involve less single-use packaging overall – limited primary data
		• Scaling up SFSC likely to require growth in domestic supply – majority of fruit and vegetables produced domestically are consumed domestically, with limited exports
		• Irish produce not necessarily the most sustainable option when out of season	

4. Conclusions & Recommendations

This study has examined how single-use packaging used in the sale of fruit and vegetables can be reduced. It was undertaken as part of the EPA's Circular Insights Series and its completion is to fulfill a statutory requirement under the Circular Economy and Miscellaneous Provisions Act 2022.[4] Its objectives were to (i) gather information and insights on the types of single-use packaging used to bring fruit and vegetables to the point of sale; (ii) gather information on the role of producers, wholesalers/distributors and retailers in specifying the type and use of single-use packaging in the sale of fruit and vegetables; and (iii) identify options for reduction in single-use packaging in the sale of fruit and vegetables. The study has been informed by a literature review and engagement with key stakeholders.

Key types, materials and functions of single-use packaging used in the supply chain of fresh fruit and vegetables have been identified, as summarised below. These packaging types fulfil a variety of functions. From an environmental perspective, the most important function of packaging is the prevention of food waste, a significant source of anthropogenic greenhouse gas emissions (approx. 8-10% globally). The precise quantities of packaging placed on the market and/or packaging waste generated associated with single-use packaging of fresh fruit and vegetables in Ireland is not known.

Single-use packaging of fresh fruit and vegetables – overview of types, materials and functions

Types	Materials	Functions
• Sticky labels • Adhesive bands • Trays, tubs and cups in various materials (including plastic punnets) • Plastic films • Plastic and paper tags • Plastic and paper bags • Plastic and bio-based nets • Cardboard boxes • Wooden boxes	• Petroleum-based plastics • Bio-based plastics • Adhesives • Paper • Paperboard • Cardboard • Wood • Composite materials (including biocomposites) • Bio-based fibres • Metals	• Protection from damage and spoilage (including prevention of food waste) • Compatibility with supply chain processes and logistics • Compliance with food safety requirements • Provision of information (including marketing) • Grouping of produce to create a sales unit • Meeting consumer expectations (e.g., convenience) • Separation of organic produce (not strictly required)

This study has investigated the supply chain of fresh fruit and vegetables for retail sale in Ireland, to understand the role of the various actors in the specification and use of single-use packaging. This study has found that large retailers are the key actors influencing the specification of packaging. Large retailers engage with and provide guidance to their suppliers regarding acceptable forms of packaging. This guidance is influenced by legislation and places an emphasis on recyclability of the packaging waste at kerbside. Conversely, smaller retailers have less purchasing power and may rely on larger retailers to create demand for alternatives such as loose produce.

This highlights the potential role that large retailers could play by leveraging their purchasing power to reduce single-use packaging and create demand for alternatives, such as loose produce and reusable alternatives. It also underlines the need to ensure that the appropriate policy instruments are in place, in accordance with the 'polluter pays' principle, to drive single-use packaging prevention among retailers,

in addition to the more established practices of material substitution (e.g., use of recyclable materials) and lightweighting with a strong focus on packaging prevention through EPR.[208]

The forthcoming PPWR is the key policy development in this area at EU level. The proposed Regulation contains a number of provisions that will drive reductions in single-use packaging of fresh fruit and vegetables, particularly the proposed ban on single-use plastic packaging for unprocessed fresh fruit and vegetables under 1.5kg from 2030 (which will promote the adoption of loose produce), and minimum targets for the use of reusable packaging in the supply chain for 2030 and 2040. National policy initiatives will focus on the adoption of measures that will support the transposition of the PPWR.

Three categories of single-use packaging reduction options were identified and examined under the scope of this study: dematerialisation, reusable packaging and SFSC (Figure 11). Specific options under these headings include lightweighting of packaging, sale of loose produce, laser labelling, B2B reusable packaging pooling systems, and consumer-level reuse.

With the exception of laser labelling, these options are already being implemented in Ireland to varying degrees. Engagement with stakeholders indicates that there is currently a strong focus in the sector on recyclable packaging and lightweighting of packaging, with relatively less of an emphasis on the other packaging reduction options identified. This is consistent with the findings of a recent study of commitments of over 950 major organisations targeting plastic pollution, which found a strong focus on recycling and recycled content with relatively less attention being paid to prevention.[209]

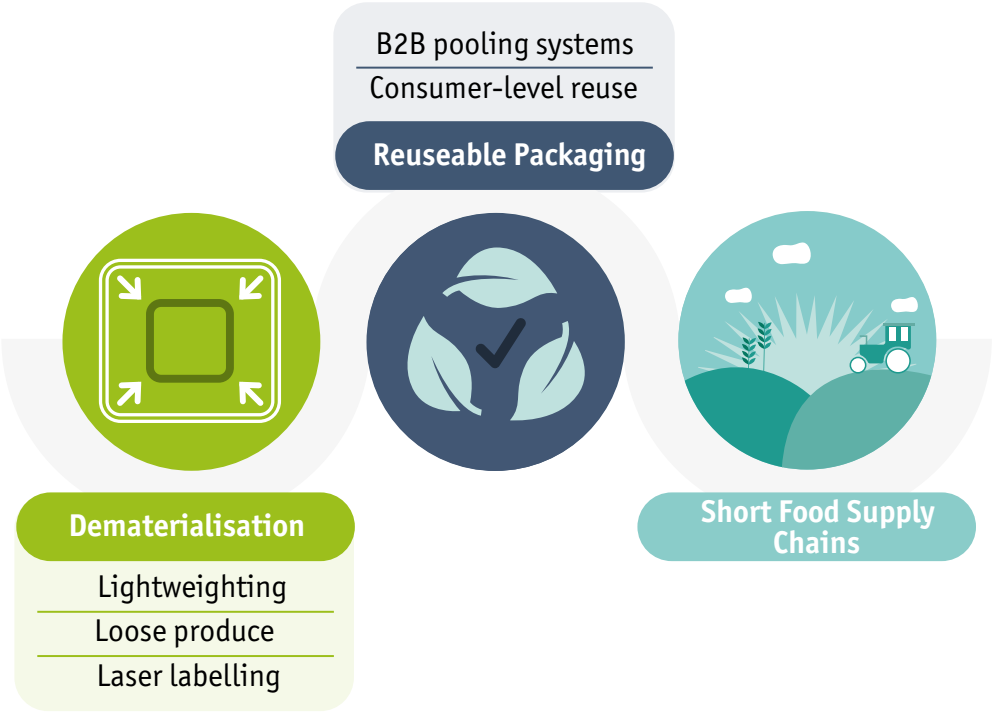

Figure 11: Options for reducing single-use packaging in the supply chain of fresh fruit and vegetables

The findings of this study indicate that opportunities exist to reduce or eliminate some types of single-use packaging currently used for fruit and vegetables in Ireland, and to improve the efficiency of reusable packaging systems in the supply chain. Its findings also underline the need to adopt a whole supply chain perspective that ultimately aims to reduce the net lifecycle environmental impacts of the supply chain, including indirect impacts on food waste.

Based on the findings of this study, the following options are recommended:

1. Promote the sale of loose produce by addressing known barriers and further developing the evidence base for its adoption (including through pilots and trials, voluntary agreements, education and awareness).

This study has highlighted opportunities to switch to loose produce, particularly in cases in which primary packaging is used for purposes other than the prevention of food waste. For example, where primary packaging is used to create a sales unit or multipack, for marketing, or to segregate organic produce, opportunities should be explored to switch to loose, where appropriate.

This study has identified potential barriers to the widespread adoption of loose produce. For example, there are limited economic incentives currently for retailers to switch to loose produce. Some retailers offer loose produce and pre-packaged alternatives for the same types of produce, making this a matter of consumer choice. Consumer research indicates a potential attitude-behaviour gap, with evidence that a proportion of Irish consumers opt for pre-packaged produce despite concerns regarding the environmental impacts of single-use packaging.[109] Consumer research undertaken to inform this study (refer to Section 3.3) reports that more transparent pricing, availability, safety and cleanness are the most common perceived advantages of pre-packaged fruit and vegetables. Pro-environment reasons, quality and flexibility with quantity are key factors in choosing loose fruit and vegetables.[107]

These factors point to the value of a policy intervention to promote uniform adoption of loose produce among retailers. As noted above, this is proposed for all Member States under the forthcoming PPWR.

Repak operates a Plastic Pledge, a voluntary agreement for its members to promote plastic packaging sustainability initiatives. A similar voluntary agreement for retailer producer members could be established, developing a phased roadmap to meet the requirements of the 2030 PPWR ban.

The relationship between food packaging and food waste is complex. Primary packaging undoubtedly plays a role in the prevention of food waste of perishable produce. However, research also suggests that excessive use of primary packaging can force consumers to purchase more than they need, contributing to household food waste.[112, 124] Research undertaken by WRAP in the UK concluded that opportunities exist to reduce both food waste and plastic packaging by switching to loose produce.[124]

Given the risk of unintended impacts on food waste, there is a need to develop the evidence base to support the adoption of loose produce and build the capacity of the sector to implement the future requirements of the PPWR.

It is, therefore, recommended that loose produce pilot projects be undertaken in retail environments to understand the likely impacts of switching to loose produce and to inform the development of best practice guidelines to support industry implementation. As part of these pilot projects, it would be beneficial to measure the impacts on surplus and food waste in the retail environment and consumer households, consumer attitudes and behaviours in response to the trials, the use of packaging in the supply chain overall, and the degree of consumer-level reuse. Education and awareness for consumers and retailers should be informed by these behavioural insights, and seek to support the purchase of loose produce over pre-packaged produce.

These pilot projects could be used to inform the development of best practice guidelines, including a loose produce decision tree specific to the Irish context, guidelines on the management of loose produce in retail environments, and the guidelines on the sale of loose organic produce. As highlighted by the Morrisons case study, the adoption of loose produce may result in temporary increases in surplus and/or food waste in the retail environment, necessitating the adoption of new approaches to managing produce.

Depending on the outcomes of these pilot projects and wider research – particularly regarding the impacts on food waste – policymakers could consider a national-level ban on single-use packaging of unprocessed, fresh fruit and vegetables under 1.5kg in advance of the PPWR. As was implemented in France (refer to case study in Section 3.4), this could include a list of exceptions for particularly perishable produce.

National packaging waste statistics are published annually by the EPA (Repak also publish data relating to their producer members). These categorise packaging waste by material type and waste treatment type. There are no data publicly available on the quantity of packaging placed on the market or packaging waste generated by sector/use. Therefore it was not possible to quantify the single-use and reusable packaging used currently in the fresh fruit and vegetable supply chain in Ireland, either overall or by individual type or material.

In order to evaluate the effectiveness of initiatives to reduce single use packaging of fresh fruit and vegetables, and to monitor progress over time, it will be necessary to determine the quantities of single use and reusable packaging used in the supply chain. It is therefore recommended that opportunities be explored to gather this information.

2. Adopt a system or systems for reusable secondary and tertiary packaging

This study has identified a potential opportunity for standardised B2B pooling of reusable secondary and tertiary packaging for the Irish grocery sector, similar to the Swedish Return System, which covers over half of the fresh produce supply chain in Sweden (refer to case study in Section 3.4.1).

Reusable packaging currently represents a tiny proportion (approx. 1% in 2021) of all packaging placed on the market in Ireland – which suggests an opportunity to scale. Furthermore, stakeholder engagement indicates that the current use of secondary and tertiary packaging in the fresh produce supply chain in Ireland is varied and fragmented. Some actors use reusable crates and pallets (which may be owned in-house or leased from B2B enterprises like Glan Arís), while others use single-use cardboard and (to a lesser degree) wooden boxes.

The introduction of an industry-led pooling system offers potential efficiencies over the current scenario – for example, through centralised back haulage, washing and maintenance, and standardised packaging. Potential avenues to support such an initiative, such as EU funding and EPR, should be explored. The Swedish Return System, for example, was established by industry trade and retail associations using start-up funding from EU LIFE. There is also the possibility that the structure of EPR fees could be leveraged to promote the uptake of reusable alternatives for secondary and tertiary packaging.

The feasibility and relative merit of implementing such a system at scale would need to be considered with regard to the likely lifecycle impacts in the Irish context. In this regard, LCA would be valuable, comparing the lifecycle impacts of using reusable plastic crates and/or reusable plastic pallets as an alternative to single-use equivalents, using scenarios representative of the Irish context.

3. Investigate potential alternative labelling technologies suitable for use in the Irish fresh produce supply chain

The requirements of the new PPWR will necessitate the development of new labelling technology. Initiatives such as compostable/bio-based labels and laser labelling methods are some of the alternatives which have been identified.

Laser labelling has been implemented as an alternative to sticky labels and other forms of single-use packaging on fresh fruit and vegetables by retailers in other countries – including ICA in Sweden, M&S and Tesco in the UK, and Carrefour in Belgium.[143, 147, 148, 150] This study found no evidence of adoption in Ireland.

A number of challenges have been highlighted for this approach, including potentially high upfront capital investment costs. However, laser labelling technology is a promising option for reducing primary packaging used for the provision of information. Laser labelling could be particularly useful to facilitate the sale of loose organic produce, where it could potentially substitute single-use plastic packaging commonly used to prevent commingling and substitution (i.e., not only sticky labels). This could have a substantial impact, given that organic produce accounts for 28.6% of vegetables and 15.0% of fruit sold in Ireland.[102]

It is recommended that industry stakeholders explore the feasibility of the alternatives for labelling in the Irish fresh produce supply chain (e.g., through a trial in the retail sector). Such initiatives should be progressed in consultation with the FSAI to ensure compliance with food safety and labelling requirements.

4. Investigate the potential of short food supply chains to optimise single-use packaging reduction for crops suited to commercial production in Ireland

A number of sources posit that short food supply chains (SFSC) may require less single-use packaging than longer, more complex food supply chains.[38. 180, 181, 183, 185] However, there is limited primary data to support this assertion, and stakeholder insights revealed mixed views in this regard.[187] It has also been suggested that SFSC could be complementary to B2B pooling systems for reusable secondary and tertiary packaging, due to reduced transport distances and complexity in the supply chain, and potentially higher rates of return.[192]

Approximately a third of the fresh fruit and vegetables imported to Ireland each year are types that can be produced domestically, including potatoes, apples, onions, carrots, tomatoes, cabbages, lettuce and soft fruits.[31, 99] Teagasc has noted that there are opportunities for Irish growers to increase domestic production and substitute a proportion of these imports – i.e., to increase the amount of fresh produce sourced from SFSC.[29, 99, 100]

It would be valuable to understand whether policies and initiatives to support SFSC and domestic production would be likely to reduce the overall use of single-use packaging in the supply chain. Research in this area is recommended and could include studies comparing the quantum of packaging used in short and long food supply chains for types of fruit and vegetables that are produced commercially in Ireland.

APPENDIX A - STAKEHOLDERS

Stakeholders engaged with under the scope of this study (workshops and/or survey) are listed below.

• Bord Bia	• Lidl
• CIRCULÉIRE	• Musgrave Group
• Department of Agriculture, Food and the Marine (DAFM)	• NJB Packaging
• Ellen MacArthur Foundation	• Organic Trust
• Enterprise Ireland	• Repak
• FoodCloud	• Saica
• Food Safety Authority of Ireland (FSAI)	• Smurfit Kappa
• Green Streets	• Teagasc
• Irish Organic Association	• Tesco
• Keelings	• VOICE

APPENDIX B - Materials Used in Packaging of Fresh Fruit and Vegetables

Petroleum-based plastics

According to Chakori *et al* (2021), plastic is the dominant material used in packaging.[38] A wide range of conventional, petroleum-based plastics may be used in packaging of fruit and vegetables in rigid, semi-rigid and flexible forms, including polyethylene (PE), polyethylene terephthalate (PET), polypropylene (PP), polyamide (nylon) and other resins.[24] Petroleum-based plastics are convenient for the production of packaging, being inexpensive, lightweight, versatile, having a high strength-to-weight ratio, and being easy to integrate into production processes.[24] From the perspective of fruit and vegetable packaging, disadvantages of plastics include their variable permeability to moisture, light and gases.[24]

Paper, paperboard and cardboard

Paper, paperboard and cardboard is another key class of materials used to produce packaging used in the supply chain of fruit and vegetables. These are sheet materials made from renewable cellulose fibres derived from wood, using sulfate and sulfite.[24]

Wood

Wood is another renewable material used in the packaging of fruit and vegetables, in the form of crates, boxes and pallets. Wooden pallets are typically produced from conifer species such as pine. Wooden boxes and crates coming into contact with produce require sanitary processing.[24]

Bio-based plastics and biocomposites

Over the past decade, recognition of environmental and social impacts associated with petroleum-based plastics has led to increased research and development of bio-based alternatives. Bio-based plastics and biocomposites are increasingly used in packaging of fruit and vegetables. The term 'bioplastics' is used to refer to a range of plastics that may or may not be bio-based (i.e., derived from renewable resources) and/or biodegradable. These include (i) non-biodegradable bio-based plastics, such as bio-based PE and bio-based PP; (ii) biodegradable petroleum-based plastics, such as polycaprolactone (PCL) and polybutylene adipate terephthalate (PBAT); and (iii) biodegradable bio-based plastics, such as polylactic acid (PLA), which is widely used in packaging.[2, 23] While PLA is biodegradable, it should be noted that studies have highlighted slow rates of biodegradation, particularly in marine environments.[210] Biocomposites comprised of bio-based fibres and other materials (such as PLA) is also an emerging class of packaging materials.[23]

Metals

To a lesser degree, metals may also be used in packaging, particularly in heavy-duty reusable packaging used for bulk packaging in harvesting and distribution (e.g., steel protection/reinforcement of wooden pallets/pallet boxes), but also in clipping wire used to seal nets used in primary packaging.[211]

Other materials

In addition to the packaging types and materials summarised above, special substances or materials may be added to packaging or packaged with the produce. For example, 'modified atmosphere packaging' (MAP) refers to the addition of a gas mixture to packaging to prolong shelf life (e.g., of salads).[52] Pads with particular functions (e.g., to prevent compression, provide moisture or absorb ethylene) may also be used.[71]

APPENDIX C - Loose Produce Decision Tree

Reproduced from WRAP (2023)[94]

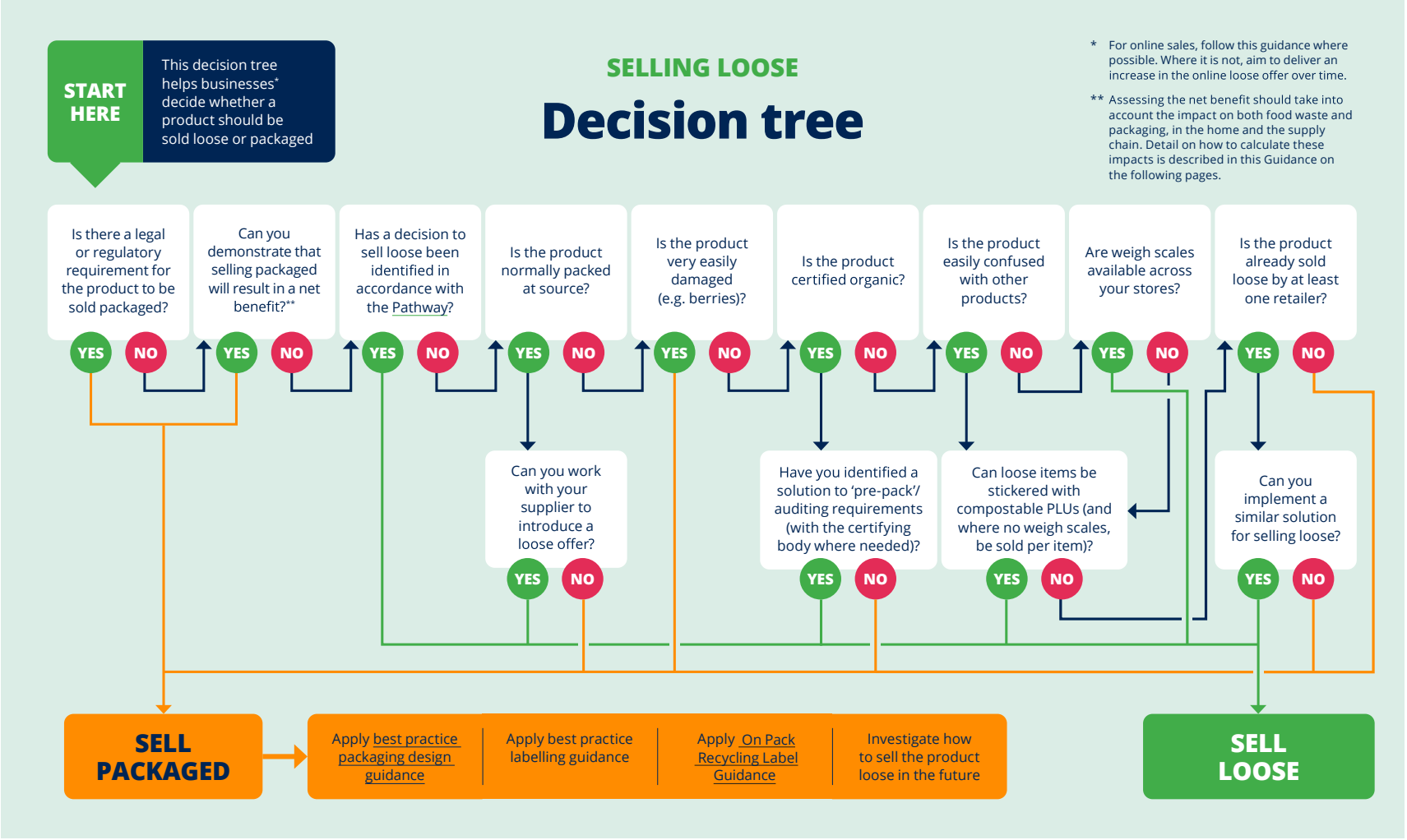

Figure 12: Loose Produce Decision Tree (reproduced from WRAP, 2023)[94]

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