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Fresh produce on the loose: Examining the coherence between plastic packaging and food waste policy using the case study of fruit and vegetables in the UK

Sarah Greenwood^{ab} (corresponding author) sarah.greenwood@sheffield.ac.uk

Christian Reynolds^c Christian.Reynolds@city.ac.uk

^a University of Sheffield, School of Mathematical and Physical Sciences, Dainton Building, Sheffield S3 7HF, UK

^b Grantham Centre for Sustainable Futures, University of Sheffield, S10 2TN, UK

^c City, University of London, Centre for Food Policy, Myddelton Street London, EC1V 0HB, UK

Abstract

The UK Fresh Produce sector (fruit and vegetables) uses 38 kt of plastic consumer packaging per year and is the fifth largest product category for the creation of plastic waste in the UK. One way of addressing this is to sell fresh produce loose, without packaging. This study takes a mixed methods approach of a literature search of historical loose produce trials and a policy coherence analysis of plastic packaging and food waste policy, addressing the research gaps in those areas. The results are used to check progress against UK Plastics Pact (UKPP) targets and alignment with Courtauld 2030 (C2030) and the United Nations Sustainable Development Goal (SDG) 12.3 on food waste. Both methods highlight a tension between food waste and plastics reduction policies at all levels and the literature survey shows there is now a will amongst retailers to overcome this. This incoherence is mitigated using caveats in the plastics policies, such as ‘where shelf-life is unaffected’. There is additional scope to harmonise further by addressing compostables and reduction targets. Supermarkets’ plastics policies are shown to be generally coherent with each other and the Pact, but implementation of individual policies between retailers varies considerably. For the removal of consumer packaging from Fresh Produce to continue, food waste in the supply chain, the amount of transit packaging used, and wider social engagement on packaging and food waste must be considered. The need for better data on packaging usage is highlighted.

Keywords: Policy Coherence, Food Waste, Plastic Packaging, Fresh Produce, Packaging-free, Circular Economy

1. Introduction

Contemporary plastic food packaging is predominantly single-use and made of made from virgin materials which use fossil resources. Global consumption is estimated to be 141 million tonnes p.a. (WRAP, 2024a). In the UK, one million tonnes of plastic packaging waste is generated annually from the food sector, with only one-third currently recycled (Morgan et al., 2020). When used correctly, packaging prevents waste by protecting and preserving the food it contains whilst providing additional functionality such as conveying information about the product and providing a level of convenience to the user (Evans et al., 2020; Parsons, 2022; Rundh, 2016).

Food waste is a critical issue with both economic and environmental implications on a global scale (Food Wastage Footprint, 2013; World Bank, 2020; WWF-WRAP, 2020). In 2022 1.05 billion tonnes of food was wasted globally in the retail, food service and household sectors combined (UNEP, 2024). In the UK 9.5 Mt of food waste is generated post-farm-gate per year, 73% of this is from households, 12% from Hospitality and Food Service, 11% from manufacture and 4% from Retail (WRAP, 2023).

Although there is a growing body of literature showing that food waste and plastic packaging waste are linked at a systems level (Chan, 2022; Heller et al., 2019; Verghese et al., 2015), they have become independent issues of public concern (Barrowclough and Birkbeck, 2022; Schanes et al., 2018). This has resulted in a tension of separate actions to reduce plastics and food waste which can be seen at the global level within the Sustainable Development Goals, non-statutory targets for countries in the United Nations (UN, 2022). Sustainable Development Goal (SDG) 12.2 focuses on all materials, including food and plastics while SDG 12.3 concentrates on the reduction per capita of food waste by 50% by 2030. In this paper we apply the concept of Policy Coherence Analysis (gov.uk, 2018a; OECD, 2021) to plastic packaging policy and food waste policy in the UK, using the Fresh Produce sector as a case study in order to examine this tension at the operational level.

The consumption of fresh produce (fruit and vegetables) supports multiple food system outcomes from improved health and nutritional diversity, enhances food security, and contributes to sustainable agriculture (Harris et al., 2022; Rekhy and McConchie, 2014). Fresh fruit and vegetables provide essential vitamins, minerals, and dietary fibre, promoting overall health and well-being (Slavin and Lloyd, 2012; Vicente et al., 2009). Additionally, prioritising local and seasonal fresh produce helps reduce the environmental impact associated with long-distance transportation and storage, as well as leading to other social or

economic benefits (Schreinemachers et al., 2018). Yet a possible barrier to increasing the consumption of fresh produce is packaging - and the consumer perceptions of this packaging.

Fresh produce is an important category for plastic packaging and food waste reduction. In the UK consumer packaging for Fresh Produce uses 38,000 tonnes of plastic p.a. making it the fifth biggest category for food related plastic packaging waste (Thomson et al., 2018).

Additionally c.2.5 million tonnes of fresh produce food waste are generated every year by households, with 500,000 tonnes of fresh produce wasted in hospitality and food service, 170,000 tonnes in the supply chain and 55,500 tonnes in retail (Parfitt et al., 2016; WRAP, 2014).

The plastic packaging used for fresh fruit and vegetables consists of ‘pots, tubs and trays’ (PTT), which includes punnets, typically made from PET or PP, and film used as lidding or to make bags, typically PE, PP or PET depending on the application (SUEZ, 2021). Only one third of pots, tubs and trays, and 7% of plastic film were collected from UK households for recycling in 2018. This compares to 59% for plastic bottles, used for Milk and Soft Drinks (Morgan et al., 2020). The fresh produce category is therefore one of the biggest challenges in terms of packaging waste management, and this is compounded by consumer pressure; press articles often question the need for plastic packaging on fruit and vegetables (Dewdney, 2018; Poulter, 2006) and pressure groups campaign for its removal e.g. (Surfers Against Sewage, 2018).

A dominant policy-led solution to reduce the amount of consumer single-use plastic packaging waste for fresh produce internationally is to eliminate consumer packaging by selling fresh produce loose: The French government introduced a law banning plastic packaging on most fresh produce in January 2022 (French Government, 2021) and the Spanish Government have announced draft legislation for implementation in 2023 (BBC News, 2021; Spanish Government, 2021). The UK charity WRAP (the Waste and Resources Action Programme) announced in December 2021 that packaging for fruit and vegetables was to be investigated for elimination as ‘unnecessary packaging’ as part of the voluntary agreement the UK Plastics Pact (UKPP) (Quinn, 2021). They are now lobbying for this to be included in legislation (Thomas, 2024).

Several in-store trials have been performed by UK retailers in recent years with the aim of selling more fresh produce loose, with only basic information on (some) of these having been reported in trade publications, e.g. (M&S, 2019; Wells, 2019). In fact, it has not been possible to find any published academic research on the loose produce trials in the UK. A review by White

and Lockyer (2020) comes the closest and Mattsson et al. (2018) have completed a study in the Swedish context.

The majority of industry and government policy on plastic packaging and food waste reduction in the UK is focused through the use of voluntary agreements (VAs). Gaining momentum in the 1990s, VAs have become a popular governance mechanism for managing environmental concerns across a number of industries at a global level (Segerson and Miceli, 1998; WWF-WRAP, 2020). In VAs public and private sector organisations make joint commitments to improve their environmental performance, without the need for direct government legislation or sanctions. In terms of food waste, these have been explored in detail in Europe e.g. via the REFRESH project which ran from 2015 to 2019 (Bos-Brouwers et al., 2020). The UK VA for food waste is the Courtauld Commitment (C2030) (WRAP, 2022b). VAs for plastics are a more recent tool; the UK Plastics Pact, the first of a series of national agreements, commenced in 2018 (Wrap, 2020). There is currently no VA for all packaging. Both are run by WRAP.

In food policy, policy coherence is defined as “the alignment of policies that affect the food system with the aim of achieving health, environmental, social and economic goals, to ensure that policies designed to improve one food system outcome do not undermine others.”(Nilsson et al., 2012; Parsons and Hawkes, 2019)

Policy coherence has been used as a method in food policy analysis to examine food security and nutrition issues (Thow et al., 2018), or to examine the coherence of wider food system policy (OECD, 2021, 2016). Parsons and Hawkes (2019) highlighted that policy incoherence across organisations in the food system often undermines the multiple objectives set in individual policies. However, there is a lack of plastic packaging and food waste policy coherence analysis in the literature.

Instead, contemporary food waste and/or plastic packaging policy analysis has focused on analysis of multilevel actors (international, national and subnational) engaged in governance and policy development of plastics (Abril Ortiz et al., 2020) or food waste (Brooks, 2014; Reynolds, 2022). In particular, there has been analysis of multi-level development and coordination of plastic packaging and food policies through mechanisms such as extended producer responsibility schemes (Diggle and Walker, 2020) or voluntary agreements (Nunan, 1999). This establishment of multi-level voluntary agreements as governance and agenda setting tools may have led individual brands and company-level targets/policies around plastic packaging to be similar to national or global policies. This process can be referred to as policy

‘harmonisation’; the shifting of regulatory requirements or governmental (or institutional) policies of different jurisdictions to be similar or identical (Drezner, 2005; Majone, 2014). However, due to systems complexities, policy harmonisation does not occur evenly. This lack of harmonisation may lead to a lack of coherence between different policies – again, this has not been explored adequately in the plastic packaging or food waste literature. There are also gaps in the academic literature reviewing the evidence on UK single-use plastic packaging waste and packaging reduction trials related to fresh produce and food waste.

This paper fills the research gaps by reviewing grey literature to document, as far as is possible, the results of these trials. The findings are then compared to supermarket packaging and food waste policies to highlight the harmonisation and coherence of the current situation with regards to the circularity of plastics in the fresh produce sector and how individual retailer policies fit in with UKPP and C2030 targets. Combined, the findings also attempt to answer the question ‘is going packaging-free the answer to the UK’s plastics waste problem?’ and suggestions for future research and policy improvements to make this happen are made, which will also be relevant to all food product categories and of interest to countries and regions that are part of the Plastics Pact Network (EMF, 2023).

2. Method

A mixed methods approach has been taken to assess the current landscape of actions and policy focused on primary packaging used for fresh produce in UK supermarkets to establish if there are tensions between packaging and food waste prevention:

Literature review: A literature search was performed between June 2021 and January 2022 covering both academic and grey literature. The platform Scopus was used to search for academic literature using the terms ‘plastic shelf life fresh produce’, ‘packaging shelf life fresh produce’, ‘loose produce’ and ‘loose produce and shelf life’ over all available articles. An internet search was performed using google with the search terms ‘produce and shelf life’ and ‘loose produce’ and ‘historic loose produce sales UK’. The UK trade magazine Packaging News’ website archive (Packaging News, 2023) was searched using the term ‘loose produce’ between 2007-2022. The search terms were chosen specifically to find trials with multiple products rather than single product lines. This search yielded just 15 references, including one academic paper (White and Lockyer, 2020), all listed in Table 1. Documents from the coherence

analysis below were also searched for references to loose produce. Relevant UK legislation, voluntary agreements and high-profile environmental campaigns have been reviewed and added to the timeline in Figure 1 in the appendix, along with the dates of loose produce trials reported by retailers.

Policy harmonisation and coherence analysis: The level of harmonisation and coherence has been analysed by examining UK level documents and guidance, and specific supermarket policies and website pages on packaging and plastics. The supermarket specific documents were reviewed to gauge progress in reducing the impact of their plastic packaging and the harmonisation of their policies to UKPP targets. These policies were then compared with the same UK level documents and guidance, and supermarkets' policies on food waste. Between the 15th and 17th Feb 2022, a Google search from a private window was performed for packaging and food waste policies. The search terms were '[name of retailer] and packaging policy' and '[name of retailer] and food waste policy' and results are saved in the Supplementary Information (S2). A total of 98 web pages and downloadable documents of interest were saved and stored in (S3). Key information was extracted manually and added to 2 spreadsheets in the supplementary information (S1a and S1b) a summary version of which is shown in Table 2. The information from each retailer was compared with the targets of the UK Plastics Pact and Courtauld 2030. To investigate the framing of specific terms related to packaging and provide further rationale for instances of incoherence between different supermarkets, Documents were internally searched for the terms 'hygiene' 'safe*', 'protect*', 'convenience*' and 'food waste'. The supermarket plastics and food waste policies were then attributed a score (-3 to +3) using the framework from (Nilsson et al., 2012) and (Nilsson et al., 2018). This was performed by SG and verified by CR.

3. Results

3.1 Literature Review – the current landscape, trials to date, legislation and voluntary agreements

3.1.2 The current landscape

It was not possible to find data on the split of loose vs packaged fresh produce in the UK before 2018. In 2018 the British Growers Association found that that 49% of fresh produce items were sold in 'plastic wrap' and 15.5% loose (Refrigerated and Frozen Foods, 2018). In 2019, major UK

retailers self-reported loose sales as between approximately 17 and 19 percent (Environmental Investigation Agency; Greenpeace, 2021) (Statista and Kantar Worldpanel, 2022). The figures for 2019 are shown in *Table 1* alongside market share.

3.1.3 Trials to date

Several trials have been run at store level by UK retailers, however it was not possible to find any published academic literature on these. Trials where (at least some of) the results have been made public by other means include from Asda (Packaging News, 2007), Morrison's (Perkins, 2021; WRAP, 2021), Iceland (Barrie, 2019) and Waitrose (John Lewis Partnership, 2021). The information released is of mixed quality with only Waitrose and Morrisons publishing anything more than top-level detail. Others have stated that they have or intended to perform trials but have not published the results (e.g. Aldi (Searle, 2020; Wells, 2019)). Table 1 contains a summary of these trials; Table S1c) in the supplementary information lists all the available information. Figure 1 (see appendix) shows a timeline of trials alongside notable legislation, commitments and campaigning.

Asda were one of the first retailers to trial selling produce loose in 2007 in five stores. This was during a period of public concern with plastic packaging, including high profile campaigning from the UK Women's Institute (Poulter, 2006). For context, this was also the time of the first Courtauld Commitment (WRAP, 2022a). In a news item Asda reported that the trial was unsuccessful - in-store spoilage rates doubled to approximately 6% caused by "acceleration of the ripening process; produce becoming damaged and not subsequently purchased; and the practical difficulties of keeping track of stock rotation" and that many customers "preferred to buy packaged produce" for reasons of convenience and hygiene (Wells, 2008).

In 2017 - around the time of a subsequent wave of plastic dissatisfaction often termed the "Blue Planet Effect" (BBC, 2017; Gell, 2019), and the introduction of the UK Plastics Pact - UK retailer Morrison's began a comprehensive 10-month trial in three stores. The project evaluation report states initial in-store waste levels were 2.7 times higher than normal, but this was brought back to average levels through improvements to store process and management (WRAP, 2021). Their intention was to roll out to a total of sixty stores with the potential to save 156 tonnes of plastic waste. The Grocer reported in 2021 that Morrison's had dedicated loose produce areas in 63 stores in 2019 and that in 2020, 332 of their 497 stores included loose produce (Perkins, 2021).

It was reported that in a customer survey as part of the trial 75% of customers preferred to buy fresh produce loose (WRAP, 2021).

Iceland Foods Ltd, who famously declared they would rid their supermarkets of all plastic packaging by 2023 (BBC News, 2018), abandoned a 2019 trial quoting a loss in sales of 30% stating “What people want is pre-packaged convenience. Lots of people pop in and spend small amounts of money. We need to keep prices low and the trial cost us more in the end.” ending with a resolution to use this as a learning experience and try again in the future (Barrie, 2019; Iceland Foods Ltd, 2019).

Loose produce formed part of the wide-ranging Unpacked trial in Waitrose in the Botley Road, Oxford store starting in 2019 (John Lewis Partnership, 2021). Waitrose reported that in-store food wastage increased at the start of the trial (due partly to “ordering too much pre-packed soft fruit”) but they do not detail the value that this levelled off to. They considered the trial a success in the reduction of the amount of plastic waste generated and they seem confident that there is scope for overall greenhouse gas reduction. Customer feedback included that there was a loss of quality of some of the naked products (thereby implying a possible increase of in-home waste). Waitrose reported that it was likely that customers would return to the packaged version if this was the case (John Lewis Partnership, 2021).

Other retailers that stated an intention to run trials but did not report detailed results included M&S, Tesco and Aldi (Edie.net, 2019; M&S, 2019; Searle, 2020) (see Table 1 for a summary).

Investigating a move in the opposite direction, Asda provoked internet outrage by experimenting with selling only pre-packed produce in 2017 (Paterson, 2017). Perhaps learning from this, they started to investigate loose produce again in a store dedicated to trialling sustainable initiatives (Asda, 2020).

3.1.4 Legislation and Voluntary Agreements

Key legislation (UK and European) with dates of introduction are shown in Figure 1, a full description of which is in Appendix B. EU legislation has been included as this is from where most current UK legislation relating to plastics and packaging is derived. Running in parallel to the work on legislation, there have been several voluntary commitments in the UK to reduce packaging and food waste (WRAP, 2022b);

3.1.4.1 The UK Plastics Pact

The UK Plastics Pact (WRAP, 2018) was introduced in May 2018. A voluntary commitment with the aim of making plastic packaging more circular, signatories agree to aim for the following targets by the end of 2025:

1. Eliminate problematic or unnecessary single-use packaging through redesign, innovation or alternative (reuse) delivery model.
2. 100% of plastics packaging to be reusable, recyclable or compostable.
3. 70% of plastics packaging effectively recycled or composted.
4. 30% average recycled content across all plastic packaging.

3.1.4.2 Courtauld 2030 (UK)

Courtauld 2030 (WRAP, 2022b) is a voluntary agreement led by WRAP that is focused on reducing food waste, cutting carbon and protecting critical water resources. It has built on previous voluntary agreements since The Courtauld Commitment, or Courtauld 1, which ran from 2005 to 2009 and addressed food and packaging waste. The packaging component of Courtauld 1, focussed solely on weight reduction, covering all materials (WRAP, 2022a). The food waste target of Courtauld 2030 is aligned with the United Nations Sustainable Development Goal 12.3 on food waste (UN, 2022). The full set of targets are:

For food waste: To deliver against UN SDG 12.3: a 50% per capita reduction in food waste by 2030 vs the UK 2007 baseline (covering manufacture, retail, hospitality and food service, and household).

For GHG emissions: To deliver a 50% absolute reduction in GHG emissions associated with food and drink consumed in the UK by 2030 (against a 2015 baseline).

For water: With an overall target by 2030 that: 50% of fresh food is sourced from areas with sustainable water management (WRAP, 2022b).

Courtauld 2030 does not include packaging, instead this is covered by the UK Plastics Pact (WRAP, 2018), launched in 2018, which focusses on plastics only

3.3 Review of Retailer packaging and food waste policies

3.3.1 Summary of retailer plastic and packaging policy

All the retailers searched for were found to be members of the UK Plastics Pact apart from Iceland, and all are members of Courtauld 2030.

Retailer policies are broadly in line with the UK Plastics Pact targets, their own dates for implementation varying. Each retailer has their own take on the Rs of sustainability – e.g. Tesco have their 4Rs of sustainability – ‘Remove, Reduce Reuse and Recycle’, M&S have ‘Refuse, Redesign, Reduce, Reuse, Recycle’ (See Table 2).

In addition to the four UKPP targets, all retailers have their own targets for the reduction of the plastic packaging (some for all packaging materials – Aldi, Lidl, M&S and Waitrose).

Target 2 of the UK Plastics Pact is for plastic packaging to be reusable, recyclable or compostable by the end of 2025. For all retailers the focus is very much on recyclability with varying, much smaller commitments to reuse. Compostable materials do not feature prominently in targets for any of the retailers. The Co-op sell compostable carrier bags and Waitrose have compostable giveaway bags for loose produce; both encourage customers to use these as food waste caddy liners. However, it is in neither companies’ policies to use compostables for consumer packaging. Tesco have compostables on their ‘red list’ of materials to be avoided, and Morrison’s quote they are not investigating the materials because of a lack of waste infrastructure. Only Iceland, who are not plastic pact signatories, say they are lobbying for composting collection to become widely available.

In their documents most retailers acknowledge the role of packaging in protecting the product (mentioning either protection, safety or hygiene) and four of the eleven explicitly mention food safety. Ten of the eleven, quote the importance of packaging in the reduction of food waste (or keeping food fresh), but are not specific about where in the supply chain the food waste savings are made (see supplementary information S2b)). Consumer acceptance (legislation.gov.uk, 2015a), and convenience, a service which is provided by to the consumer by plastic packaging (Evans et al., 2020) and can be considered a subset of acceptance, however, are mentioned considerably less – only 3 of the 11 mention or allude to this (e.g. Morrisons state that it must be ‘in a form suitable to meet the customer’s needs’).

3.3.2 Summary of retailer food waste policy

Food waste policies are simpler and vary less between retailers. All the retailers examined are signed up to Courtauld 2030 (see 3.4.1.2), in line with the United Nations sustainable development goal 12.3. Here food waste is targeted from farm to fork – i.e. in manufacture, retail, hospitality and food service, and household. There is a focus on operational food waste with nine of the eleven retailers stating this explicitly, four retailers expand on this and discuss supplier and / or customers waste, and two of the retailers discuss food waste in a mere general sense (Supplementary material S2a)). As with plastics, individual retailers may publicly set themselves interim targets and these differ from retailer to retailer.

Ten of the eleven retailers acknowledge the role of plastic packaging in reducing food waste in when used appropriately (Dhall, R.K., Sharma, S.R. & Mahajan, 2012), although they tend to generalise by stating ‘the supply chain’ and do not specifically state whether this is in-store or in-home. (Supplementary information S2 b)) Plastics packaging and food waste policies are generally aligned for all of the retailers.

3.3.3 Policy Analysis

Table 3a shows the results of the coherence analysis of the four targets of the UKPP and the food waste component of Courtauld 2030. Table 3b shows the results of the coherence analysis to their plastics and food waste policies detailed in Table 2 in relation to the UK Plastics Pact, Courtauld 2030. Table 3c shows the scheme for allocating scores. The results are discussed in 4.2.

3.3.3.1 Policy Coherence Analysis - UKPP Aims, Individual target and food component of C2030

Table 3a shows a Policy coherence analysis of the UKPP individual targets compared to each other, the headline aims of the pact (Wrap, 2023) and the food component of C2030, using the coding scale in Table 3c. Here the score is the impact of the target in the rows on the target in the column. Progress on Target 1 automatically means progress in Target 2 and enables targets 3 and 4. Target 1 increases the circularity of plastic when non-recyclable plastics are replaced with recyclable plastics, and items that are replaced by materials substitution mean that there is less plastic packaging waste in the environment, e.g. in landfill or through being littered (although not necessarily less packaging waste of other materials).

Once Target 2 is met, this provides the conditions for Targets 3 and 4 to progress; Target 3 is then largely dependent on collection and reprocessing infrastructure, which is outside of the direct influence of most pact members. Target 4 depends on the availability of the right quality of recycled material, which will be enabled by progress on Target 3.

Targets 3 and 4 follow on from Targets 1 and 2 and progress on 3 and 4 have less impact on the progress of 1 and 2, hence the lower scores.

To summarise, the four targets of the UKPP are all aligned with each other to varying degrees and with the umbrella aims of ‘increasing the circularity of plastics and reducing the amount of plastics in the environment’ (here taken to be in landfill / as litter).

Some plastic packaging has excellent food preservation properties but is either not recyclable or does not currently have a viable recycling stream - e.g. multi-material multilayer flexibles (Soares et al., 2022). Moving to widely recycled alternatives could mean a loss in barrier, and hence product shelf life. Progress on Targets 1 and 2 could constrain progress on food waste target (-1 values in Table 3a) column 8). However, the WRAP guidance on selling uncut fruit and veg states explicitly that packaging should not be removed if it affects the amount of food waste. This caveat, that food waste should not be affected is implied in other areas - e.g. p14 of the UK Plastics Pact Roadmap to 2025(WRAP, 2022d), which states that a difficulty of moving from multilayer structures is finding nanomaterials with equivalent barrier properties.

Examining the food waste target for C2030, there are no such caveats for the impact on plastic waste, hence the values of -1 in row 5, resulting in a dominance of the issue of food waste over plastic packaging waste. Progress on food waste targets may require food suppliers to keep using non-recyclable packaging, hence slowing progress in the increased circularity of plastic food packaging.

3.3.3.2 Policy Coherence Analysis - retailers plastic and food waste policies compared with the UKPP targets and the C2030 Food Waste Goal

Table 3b shows a Coherence Analysis of the Retailers’ policy as related to ambitions of the UK Plastics Pact, and Courtauld Commitment.

Retailers’ Plastic Policies

All retailers apart from one score 3 against UKPP Target 1 for the elimination of unnecessary items. The outlier, Ocado does not provide explicit information on this so is marked as a 1 and has been scored the same against Targets 2-3 for the same reason. Target 2 of the UKPP is for 100% of plastic to be recyclable, reusable, or compostable. Consequently, only one of these three has to be met for the goal to be achieved. E.g. Tesco have an anti-compostables stance, but the remaining packaging could be recyclable or reusable, so Tesco Plastic scores 3 vs UKPP Target 2. Retailers' plastic policies mainly score a 2 against T3 as they enable recycling, but they don't actively engage in recycling at scale (other than Morrisons who pledged to recycle as much plastic as they put on the market in their own facilities (17)). Retailers' plastic policies score 3 against T4 if they explicitly state they are targeting 30% or more recycled content and 2 if they are 'working towards' (as with Tesco).

10 of the 11 retailers acknowledge the benefits of plastic in preventing food waste, hence the score of 0 for retailer plastic policy against the food waste component of C2030.

Retailers' Food waste policies

For all retailers the food waste policy scores 3 against the food component of C2030, -1 against T1-T3 of the UKPP and 0 against T4. The food waste policies are all in line with the food component of C2030. The role of plastic packaging in the reduction of food waste is acknowledged by all retailers, therefore a score of -1 has been allocated to T1-T3 as it may be necessary to keep hold of non-recyclable or non-widely recycled packaging specifications, identified in Target 1 (often called by WRAP and retailers 'difficult to recycle') in order to maintain/reduce food waste levels. 0 has been allocated to T4 as there is no correlation between recycled content of plastic packaging and food waste.

4. Discussion

4.1 Fresh Produce

4.1.1 Trials

Reporting of supermarkets' loose produce trials provides only limited data, however some useful information can be obtained. Asda's 2007 trial (Packaging News, 2007) highlighted the complexities involved in selling produce loose. Work by Paiva and Ugraya, (2024) who found that instore wastage increases due to product being damaged by handling and then subsequently not purchased and Mattsson and Williams (2022) who emphasise the need for careful stock rotation supports this. The doubling of in store waste at Asda was, at the time, considered evidence enough not to continue, illustrating the function of packaging in preventing food waste at the store level. However, a key finding of this review shows that in the period from 2018 onwards, following Blue Planet II and the launch of the UKPP, there is now an apparent drive to overcome this phenomenon. Similar levels of wastage to the Asda trial were initially experienced by Morrisons and Waitrose in 2018 and 2019 (John Lewis Partnership, 2021; White and Stanmore, 2018) yet on these occasions, there was a will to find solutions to bring the waste figures down. M&S did not make waste figures public, though they stated that their Tolworth trial was successful and rolled out more loose lines across their stores (M&S, 2019). Iceland expressed a wish to try again following their abandoned trial of 2019, and Asda themselves announced another attempt in 2020 (Asda, 2020).

There is no information available however, on additional costs to the businesses. It is possible that the process improvements Morrisons implemented require ongoing additional staff-time and resources, as indicated in Mattsson et al. (2018). Likewise, there is no information on any additional costs to employ the trained greengrocers that M&S deployed for the Tolworth trial. Furthermore, there is no mention of any additional secondary packaging required to protect the produce through the supply chain, even though this is an important function of packaging in this context (Verghese et al., 2015).

Consumer acceptance is an essential factor in moving to loose fresh produce. Asking time-poor consumers to have to start selecting their own fruit and vegetables may prove to be a challenge. The loss of the convenience of packaged goods was reported as a factor in the failure of the 2007 Asda and 2018 Iceland trials, although a survey performed as part of the Morrisons trial is more positive, stating that just 25% of customers preferred packaged produce (WRAP, 2021). This difference could be attributed to a difference in demographics between the stores'

customers or possibly an example of the Intention-Behaviour Gap (Sheeran and Webb, 2016). The loss of packaging also means the loss of a communication channel with the consumer (Lindh et al., 2016) and a perceived reduction in hygiene of the product (Wells, 2008; WRAP, 2021). This highlights that cultural and social factors could have a strong role in plastic packaging reduction. It is interesting that less than half (3 of the 11) of the retailers in this study acknowledge consumer acceptance as an issue and this warrants further investigation.

4.1.2 Alternatives to selling Fresh Produce loose

Selling loose is not appropriate for all produce items, especially those with high respiration rates such as spinach or salad leaves. In these cases, 1) lightweighting of packaging components, and/or 2) for packaging to be 100% reusable, recyclable or compostable (UKPP target 2) are more appropriate than elimination of reduction of plastics packaging waste. Additionally, the optimisation of pack sizes and the introduction of added packaging features have the potential to minimise both food waste and packaging waste. Each of these is discussed in Appendix C.

4.1.3 The future for Fresh Produce

Following trials on Apples, Bananas, Broccoli, Cucumbers and Potatoes by WRAP (WRAP, 2022e), the current recommendations are that uncut fresh produce is sold loose “as long as shelf-life is unaffected” (as well as the removal of best before dates and for most items to be stored at under 5°C). This means that plastic packaging on uncut Fresh Produce will now be considered for elimination in Target 1 of the Plastics Pact, and signatories will be asked to consider its removal. The relevant members have now been set targets to investigate a minimum number of uncut produce lines within a set timeframe before the end of 2025 (Conroy, 2023), the delivery date for the targets of the UKPP.

The studies included in (WRAP, 2022e) only measure the shelf-life of loose vs packed produce in simulated home conditions. The supply chain up to the point of sale has not been considered, nor has the shelf-life, and hence the amount of food waste of the produce while on display, or conversely if extra secondary packaging may be required to maintain existing food waste levels (Verghese et al., 2013). Additionally, a study by the UK Food Standards Agency has shown that over 50% of UK domestic fridges are kept at a temperature over 5°C, indicating that there will be an impact on global warming potential if the recommendation for households to store

under that value are actioned by householders. A key recommendation from this paper is for future research to expand to cover the entire Fresh Produce supply chain considering the tensions between food and packaging waste levels and CO₂ emissions.

This future work would support retailers and their suppliers in investigating alternative systems and technologies to reduce single-use packaging whilst avoiding increasing other environmental impacts associated with food waste throughout the entire supply chain.

In addition to considering the total environmental impact, the introduction of these alternative technologies must also carefully consider the multiple trade-offs between cost, culture, consumer acceptance and convenience.

4.1.4 Limitations - availability and accuracy of information

The figures from the British Growers Association and Greenpeace/ EIA suggest the amount of Fresh Produce sold loose in the UK is somewhere between 15% and 18%. It is most likely that this figure is by the number of lines (stock keeping units) on offer rather than sales volumes, so gives a limited picture. It would be useful for there to be publicly available information on the relative sales volumes.

Similarly, the amount of plastic packaging used in the Fresh Produce (or any) category is difficult to estimate accurately: WRAP report (Thomson et al., 2018) that of the 141kT of Pots Tubs and trays placed on the market in 2017 28% was used in Fresh Produce. This works out as 39.5 kT, not including flexibles, yet the total amount of packaging used in fresh produce is estimated to be just 38kT. Consumer film placed on the market in 2017 in total was 375kT. Making the very broad assumption that the same proportion of films is used in the produce category as in pots tubs and trays, this would make the amount used 105kT, which is clearly incorrect. This illustrates the need for more accurate data on the weight of packaging used.

As there is little academic literature on the subject, information on trials has been extracted from news and trade publications and retailer websites. This information is limited in nature, it is also likely that additional trials have been performed but not reported on, especially if unsuccessful.

4.2 Policy (in)coherence and implications

4.2.1 Plastics

The results in Table 3a) demonstrate that the 4 targets of the UKPP are aligned with each other and the agreement's overarching goals. The results in Tables 2 and 3b) show that 10 of the 11 retailers examined in this study are signatories of the UK Plastics Pact, and most of their individual targets are aligned with the pact, ensuring that at a top-line level their plastics policies are harmonised. The outlier, Iceland, is aiming to eliminate all plastic by substitution with other materials. Despite Iceland's non-participation in the UKPP, their plastics policy scores in Table 3b) are in line with other retailers - this is because although their plastics reduction target is bigger, they still acknowledge that some plastic will be required in the interim and their policy for the remaining targets is in line with the UKPP targets. Note that for retailers the targets are for their own-brand packaging, although some put in aspirations for their suppliers' packaging (it is difficult to view information for suppliers to the retailers on public websites, but a high proportion of suppliers will also be signatories).

Elimination is not unique to Iceland, all but one of the other retailers examined also have a target for plastics elimination in addition to the UK Plastics Pact targets. These additional targets are for between 15% and 50% reductions - 6 are plastics only, 4 are for all packaging materials, and one has no specific targets (see Tables 2 and 3b). Alone, these additional reduction/elimination policies would also have the potential to undermine the food waste goal of the C2030. This is because these reduction targets are very ambitious (Greenpeace, 2020) so retailers risk either not achieving their own packaging reduction goals or by substituting other materials that are not as good at protecting and preserving the contents, increasing the amount of food waste. This is addressed by 10 of the 11 retailers acknowledging the role plastic packaging plays in preserving food (Table 2), and in UKPP guidance (wrap 2022h). Additionally materials substitution may result in unintended consequences such as an increase in the carbon footprint of the packaging component itself, although this is outside the scope of this study.

One aspect of the UKPP where the retailers are almost all aligned with each other, but not the UKPP agreement itself is the introduction of compostables – only two of the eleven, Iceland and the Co-op, have a strong positive stance towards these materials. The others have no targets for the introduction of compostables with Tesco instructing its suppliers not to use them (see Table 2). Potential reasons for this are discussed in Appendix C.4. Although this general negative stance does not affect whether Target 2 of the pact is met, for policy alignment and

(in)coherence this presents either an opportunity to modify the rules of the pact to align with the retailers, or for the targets in the commitment to be strengthened, e.g. by separating out compostability and reuse targets. In either case, this shows an interesting issue of policy harmonisation.

Wider aspects of the retailers' individual policies are fragmented. For example, Tesco targets all materials, not just plastic for recycling and Morrisons have made a commitment to recycle the amount of plastic they put onto the market in their own facility. The reason for these fragmented objectives may be as a response to the gap between legislation and previous commitments, and also the much higher expectations of consumers (e.g. because of campaigning from the UK's Women's Institute in the mid-2000s (Poulter, 2006)). The fragmented policy goals could also be a result of setting the goals most achievable for each retailer's operations, or even to gain a competitive advantage to be 'the first to...' as is seen in some of their policies e.g. (47) and (8) in (Supplementary information S3). This demonstrates innovation being chosen over what works in other contexts and these different objectives and policies at the supermarket level may hinder the collective ambition. This is not reflected in the scores in Table 3b as these differences could slow down progress, but not inhibit it. It might be argued that moving projects that address plastics waste to a pre-competitive collaboration may yield more effective results in the long term.

4.2.2 Food Waste

All eleven of the retailers are signed up to Courtauld 2030, the targets of which are the reduction of food waste by 50%, GHG emissions associated with food and drink by 50% and 50% of fresh food sourced from areas with sustainable after management (WRAP, 2022b). The food waste part of the commitment is for all stages where food waste can occur from 'farm to fork'. The retailers' policies on food waste are simpler than for plastics and more aligned with each other. The reason for this could be because of a longer presence of VAs in the food waste policy space, the rapid rise of concern of citizens around plastic waste over food waste in 2017-2020, and that the implementation of solutions are more complex for plastics than for food waste.

4.2.3 Packaging and Food Waste

At the top level, the food waste (Courtauld 2030) and plastic (UKPP) voluntary agreements are incoherent – plastic packaging can extend shelf-life and hence reduce food waste in the supply chain. However, WRAP use the caveat 'where shelf-life is unaffected' when recommending

the removal of consumer packaging from Fresh Produce in the UKPP (WRAP, 2022e) and it is implied in other areas (WRAP, 2022d) which can be seen as an attempt to harmonise the UKPP and Courtauld 2030. In line with this 10 of the 11 retailers state the importance of packaging to prevent food waste or keep food fresh. Less than half of the retailers, however, acknowledge that packaging provides convenience to and must be acceptable to the consumer (see Table 2). It is proposed that this is to avoid appearing to direct the blame of the plastics problem onto the consumers themselves, and instead focus on systems level solutions.

To summarise, the voluntary agreements the UKPP and the food waste part of C2030 support the UK national ambitions set out in the 25-year environment plan. At the top-level the UKPP and the food waste component of C2030 are incoherent, but caveats, explicit and implied, in the UKPP help mitigate this and help to harmonise the policies. Supermarket level policies on plastic packaging and food waste are generally aligned with each other and with the national level ambition. The fact that there are caveats in the UKPP, but not C2030 indicate dominance of food waste policy over plastics.

Although most retailers are not actively working on compostables, and the use of reusables is limited, this does not affect coherence with the UKPP, as there are not specific targets for these solutions, only collectively with the dominant solution, recyclability. However, despite the general alignment, there is also a lack of coherence and harmonisation between supermarket policies at a more granular level. Fragmented supermarket objectives and policies may arise from the need for “competitive edge”: enacting policies that are easy to implement structurally, and appeal to the specific retailer’s supermarkets clientele. This presents an opportunity for further improvements in future iteration of the voluntary agreement (WRAP, 2024b)

The UKPP is the first of the national plastics pacts and any changes to subsequent iterations are likely to influence the development of the other agreements, and the development of the UN Plastics treaty (www.plasticstreaty.org, 2022).

4.2.4 Implications for the wider food systems and environmental impacts

The study highlights a tension between food waste reduction policies and plastics reduction policies. The policy coherence of food waste and packaging policies with other food system policies is underexplored, yet both (and their co-benefit of increases to fruit and vegetable consumption) offer avenues to improve wider health, economic, social, environmental or

political food system outcomes (Caleffi et al., 2023). Our research also highlights that action by retailers (inline with voluntary agreements) offers potential avenues and barriers for wider system change, as well as new business opportunities and cost savings from reducing food waste and packaging.

5. Conclusions and recommendations

Selling fruit and vegetables loose will not solve the problem of plastic packaging waste from fresh produce alone, but it will be part of an integrated solution alongside other strategies including the increased recyclability of the packaging components. Retailers have largely harmonised their plastics packaging and food waste policies with the UK Plastics Pact and Courtauld 2030 best practice, but there are still differences in adoption between retailers. Likewise, there remains incoherence and tension between plastic packaging and food waste policies for both the sector, and individual retailers. There is still progress to be made in recycling - collection rates still need to improve for pots, tubs and trays and the material is cascade-recycled rather than closed-loop recycled. Flexible packaging (i.e. bags and films) poses the biggest challenge in terms of recycling although improvements are being made to the collection, sorting and processing of packaging films. As kerbside collection for flexibles is not due for introduction in the UK until 2027, it will not be before then until the problem of plastic waste from the Fresh Produce category, at least from the perspective of the consumer, will be solved. Whilst the case study in this paper has been on Fresh Produce in the UK, the recommendations will be applicable to all food categories and in countries that are part of the Plastics Pact Network.

Key findings and future considerations are:

- 1) Grey literature has shown there is a renewed interest in attempts to remove the consumer packaging from Fresh Produce and now a will to mitigate the potential creation of in-store food waste, rather than abandon trials because of it. Given that plastic for uncut produce has now been added to the UK Plastics Pact Target 1 for the reduction of unnecessary items, we may expect to see the revived interest in selling produce loose continuing with further trials.
- 2) This review shows that future trials must carefully monitor any impact on food waste and environmental metrics throughout the supply chain, not just households,

any additional secondary packaging required and consumer acceptance. Future policy changes must also be carefully monitored for wider impacts on food waste throughout the supply chain. Wider social engagement on both food and packaging waste could be key to achieving consumer acceptance of loose produce over the convenience and perceived hygiene benefits of packaged produce.

- 3) There needs to be more accurate data available on the sale of loose vs packed Fresh Produce and the amount of packaging placed on the market in order to monitor progress.
- 4) The global tension between food waste policy and materials resource translates to UK retailers' operational policies on food waste and plastic waste. There is an attempt to mitigate this via the UKPP e.g. by using the phrase 'where shelf-life is unaffected' in guidelines for the removal of packaging from Fresh Produce. Conversely there are no such caveats in food waste policy, indicating its dominance over plastic waste policy.
- 5) Retailers' plastics policies are largely aligned with the goals of the UKPP. However there are notable exceptions 1) Compostable plastics do not feature significantly in retailer's policies and 2) ambitious additional targets at retailer level for the reduction of plastic packaging have the potential to undermine the food waste goal of C2030 by encouraging substitution by other materials which may not be as good at preserving the contents. For 1) This provides the opportunity for policy makers to make changes to increase alignment - e.g. either strengthen the targets for compostables (or remove them). Progress on the ambitious targets in 2) is already restricted by materials substitution guidelines.

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7. CRedit author statement

Greenwood: Conceptualisation, Methodology, Investigation, Visualisation, Writing - Original Draft, Review and Editing.

Reynolds: Conceptualisation, Methodology, Visualisation, Supervision, Funding Acquisition, Writing - Review and Editing

8. Declaration of Interest

The wider project team for NE/V010654/1 included WRAP, who input into the main project on a consultancy basis.

Greenwood was employed as a Packaging Technologist at Asda at the time of their loose produce trial in 2007 which she had no involvement with. She also worked as a part-time contract Packaging Technologist at Iceland Foods in 2017-18 and as a contract Packaging Specialist at WRAP in the summer of 2018.

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From 2017 to 2020, Reynolds was employed by WRAP as Technical Specialist in international food sustainability.

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7.0 Appendices

Appendix A – Tables and figure

Table 1. Loose Fresh Produce sales percentages and historic trials listed by retailer along with policies on reduction, reuse, recyclability, recycled content and compostability

Retailer	Market share % ‡	% sold loose†	Trials of loose F+V	Results reported?	Reduction targets	Compostable targets	Recyclability and recycled content targets	Reuse targets
Tesco	27.3	17.0	2019 (Edie.net, 2019)	No	All materials 50% by weight by 2025 (1)	No – on materials ‘red list’ (4)	Fully recyclable by 2025 (1)	Trialling reusable at scale with Loop but no Specific target (6)
Asda	14.9	-	2007 (Packaging News, 2007; Wells, 2008). A loose produce trial in Southport store expanding to 4 other stores. 2017 – pre-packaged only 2020 (Asda, 2020)	“in-store spoilage rates doubled to approximately 6% caused by acceleration of the ripening process; produce becoming damaged and not subsequently purchased; and the practical difficulties of keeping track of stock rotation.” (Wells, 2008) Abandoned (Paterson, 2017) No	3 bn pieces by 2023 and 15% reduction on a like-for-like product list by 2021 (14)	No	‘Maximum recyclability’ (14)	40 products before 2025 (14)

Sainsbury's	15.3	22.0	No trials announced	<p>“Plastic has already been removed from organic bananas, easy peeler citrus fruit and single loose cauliflowers and brassicas” (9)</p> <p>Plastic trays are being removed from asparagus and sweetcorn (144 tonnes); cream pots (114 tonnes); tomatoes (102 tonnes); carrots (38 tonnes); and herb pots (18 tonnes) (8)</p>	Plastic 50% by 2025 (9)	No	<p>No specific target for recyclability</p> <p>“Removing and replacing difficult to recycle plastics including black plastic, PVC, and polystyrene by 2021”. (48)</p> <p>‘By 2023... as containing at least 30 per cent [recycled content]’ (48)</p>	Mention specific small refill trials (9,48) and encourage use of reusable bags for fresh produce but no targets.
Morrisons	10.4	24.4	2018 (WRAP, 2021). 10-month trial in 3 stores	Initial waste levels 2.7 times higher than normal but brought back to normal through store process and management 332 of 497 stores in 2021 (Perkins, 2021; WRAP, 2021)	Plastic 50% by 2025 vs 2017 baseline (16)	No – policy not to use (16)	<p>No specific recyclability target but by 2022 - Replace all coloured PET packaging with clear; removal of polystyrene; removal of PVC film, EPS, non-detectable black plastic and Rigid PVC already banned (16)</p> <p>Target for 30% recycled content (16)</p>	Encouraging Refill (e.g. at deli counters) (17) (Discounts 25p discount for refillable cup, pods for detergent bottles)
Aldi	7.9	19.0	2019 - extended a trial already running in Scotland on 5 loose produce lines to other	No update	Plastic 50% by 2025 (against	Doesn't state, but only teabags changed over	Eliminate problematic plastic packaging (black plastic, PVC and EPS_	"we are pleased to announce that throughout

			<p>areas of the UK (cabbage x 4 and Cauli) (Wells, 2019)</p> <p>In September 2020 start selling loose produce lines in 77 stores by the kg. (Searle, 2020).</p>		<p>2019 baseline) ALL Packaging 50% by 2025 against 2017 baseline (20)</p>		<p>from core range food by 2020 (done) (20)</p> <p>50% of plastic packaging to be made of recycled content by 2025 (20)</p>	<p>2021 we have been working to increase our reuse and refill transaction stations) (20)</p>
Co-op	6.2	15.0	<p>No trials announced other than Single-item trial on Cucumbers c. 2018 (White and Stanmore, 2018)</p>	<p>“The [supply chain] waste on wrapped over the 4 weeks averaged 1.33% and unwrapped 4.77% (White and Stanmore, 2018)</p>	<p>15% plastic reduction by the end of 2022 (2018) (39)</p>	<p>Single use carrier bags only (35)</p>	<p>All Co-op own-brand packaging will be easy to recycle by Q2 2021 (home collection or collection of film in stores) (39).</p> <p>We’re committed to using a minimum of 50% recycled content in PET bottles, pots, tubs, trays and punnets and HDPE bottles by the end of 2021 (39)</p>	<p>No mention of reusables</p>
Lidl	5.7	17.0	<p>No trials announced</p>	<p>Nothing reported, other than introduction of reusable produce bags for existing loose (62) in Supplementary Information, S3</p>	<p>Plastic 40% (21)</p>	<p>No</p>	<p>By 2025, 100% of own label & branded packaging to be recyclable, reusable, refillable or renewable.</p> <p>By 2021, 30% of own label plastic packaging</p>	<p>Introduced reusable produce bags in 2019 (21) Target to double reusable/refillable offering by</p>

							to contain recycled content (Complete)(21)	2021 (21) Encourage customers to bring own bags / produce bags, introduced refillable detergent spray (62)
Waitrose	5	20.0	2019 'Unpacked trial' (John Lewis Partnership, 2021)	They reported "Some in-store food wastage" at the start of the trial, but confident scope for overall reduction of greenhouse gas emissions. Plastic reduced, customer feedback that some products loss of quality. Most comprehensive assessment of GHG emissions (John Lewis Partnership, 2021)	Plastic 50% by 2025 (45) All Packaging by 1/3 by 2023 (44)	No - Giveaway produce bags only (42)	Plans to remove black plastic and Polystyrene Plastic packaging on own brand and brand 100% recyclable by 2021 and made from 30% recycled content (44)	Mention refillable trials but no targets (40)
Iceland	2.1	3.0	2019 Loose trial in one store (Liverpool) for 3 months 35 lines sold loose and 27 in 'plastic-free' packaging. Loose fruit and vegetables offered at a cheaper price than pre-packed (Iceland Foods Ltd, 2019)(24) Also trialled	Trial abandoned quoting loss of sales of 30% (Barrie, 2019)	100% removal by 2023 (24)	Lobbying for waste stream for compostables (24)	Remove PVC and Black Plastic, focus on the more recyclable plastics in decreasing amounts (24) no mention of recycled content. Introduced reverse vending machines for plastic bottles (58)	No mention of consumer reusables

			paper bands for bananas rather than bags (24)					
Ocado	1.4	0.01	-	-	-	-	Eliminated PVC, PS and Black Plastic, take carriers back for recycling ‘...make continual improvements to its recyclability and recyclable content.’ (99)	-
M&S	Part of ‘other multiples’ 1.9	5.0§	2019 - Trial in Tolworth store with trained greengrocers to offer customers advice (M&S, 2019) (Also a single-product study on apples – 2003 (White and Stanmore, 2018))	‘... we’ve rolled out over 70 loose produce lines following a successful trial at our Tolworth store, and we’re continuing to trial an additional 25 loose product lines at our test-and-learn renewal stores.’ ((27) in Supplementary Information, S3	Plastic 30% by volume by 2027 (27)	No	100% of our food packaging to be recyclable by 2022 (27). Over the next 5 years we will increase our recycled content in any remaining plastic to 50% and reduce our overall packaging tonnage by 25% (27)	‘25% of our store estate to offer our packaging-free ‘fill your own concept by 2023’ (30)

†EIA / Greenpeace figures self-reported by retailers, Asda did not report ‡June 2019 (Statista and Kantar Worldpanel, 2022) §M&S figure

Number in brackets indicates document saved in supplementary information, S3, Note packaging reductions are for own-branded products unless otherwise stated.

Retailer	Tesco	Sainsbury's	Asda	Morrisons	Aldi	M&S	Co-op	Lidl	Iceland	Waitrose	Ocado
UKPP member?	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
1. Eliminate problematic or unnecessary single-use packaging	Y + all materials	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
2. 100% of plastics packaging to be reusable, recyclable or compostable Recyclable	Y	Y	Y	Y	Y	Y	Y	Y	n/a	Y	Limited info
Reusable	Y	Y	Y	Y	Y	Y	Y	Y	n/a	Y	Limited info
Compostable	N	N	N	N	?	N	Carriers	N	Y - lobbying for waste stream	Produce giveaway bags only	Limited info
3. 70% of plastics packaging effectively recycled or composted	Y	Y	Y	Y	Y	Y	Y	?	n/a	?	Limited info
4. 30% average recycled content across all plastic packaging.	'contains recycled content where possible'	Say they are working towards (8)	Y	Y	Ambiguous.	Target to exceed	Achieved and target to exceed	Ambiguous	n/a	Not much on recycled content - (ready meal trays)	Limited info
Strategy name / description?	4 Rs (Remove Reduce Reuse Recycle)	Reduce by 50% by 2025 - Removed Reduce Replace Recycle	3 Rs of waste management (Reduce Reuse Recycle)	Plastic and Packaging Policy	7 Plastic and Packaging Pledges	Plastics Plan- 5 Plastic Principles - Refuse, Redesign, Reduce, Reuse and Recycle	Action on Plastics. Across supply /disposal chain.	Circular motion' strategy - Reduce, Recycle, Reuse, Engage, Collaborate (21)	#TooCoolForPlastic Complete removal by 2023	Taking Action on Plastics	Very little info other than part of UKPP
Plastic reduction target? - Plastic	-	50%	3 bn pieces	50%	-	30% (2027)	15% (2022)	40%	100% (2023)	50%	-
Packaging reduction target? - All packaging	50% by 2023	-	-	-	50%	-	-	25%	-	One third	-
Paper and Board	All paper and board used will be 100% sustainable by 2025	-	-	-	Y	-	-	Y	-		
Acknowledgement re food waste prevention	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	-
Acknowledgement of protection, (protection, safety, hygiene)	Y	Y	Y	Y	Y	Y	Y	Y		Y	
Consumer acceptance/ convenience	-	-	Y	Y	-	-	-	-	-	-	Y
Courtauld 2030 Signatory? (WRAP, 2022b)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Reference document in supplementary information S3	1,3,4,6,10,11,12,46,47, 51, 94,102	7-9, 12a, 13, 48, 49, 76	14, 15, 60, 61, 86, 89	16-19, 83, 95, 101	20, 20a, 65, 72, 74	27-34, 50, 69, 77, 82, 85, 87, 88	35-39a, 70, 73, 75, 79, 80, 91, 92	21-23, 53-55, 62, 97-99	24-26, 56-59	40-45, 78, 90, 93, 103	52, 63-64, 71, 96, 104

Table 2 – Summary of UK Supermarket Plastics, Packaging and Food Waste Policies (See ‘Detailed Retailer Policy Spreadsheets’ in the Supplementary Information for more detail)

Policy	UKPP				Headline aims of pact			C2030 (food waste only)
	T1	T2	T3	T4	Increase circularity of plastics	Reduce plastics in the natural environment - Litter	Reduce plastics in the natural environment - Landfill	
T1	-	3	1	1	3	3	3	-1 (0 *)
T2	1	-	2	2	3	0	3	-1 (0 **)
T3	0	1	-	1	3	0	3	0
T4	0	0	0	-	3	0	2	0
C2030 (food waste)	-1	-1	-1	0	-1	0	-1	-

* With the caveat that packaging for uncut loose produce should only be removed if food waste unaffected, and tacitly implied for others. ** with IMPLIED caveat that shelf life is unaffected. Target 1, T1 is the elimination of 13 unnecessary items, PVC and EPS, T2 is for 100% of plastic packaging to be reusable, recyclable or compostable, T3 is for 70% of plastics to be effectively recycled or composted, T4 is for plastic packaging to contain 30% average recycled content.

Table 3a, Policy coherence analysis of the UKPP individual targets compared to each other and the food component of C2030, using the coding scale in table 3c. Here the score is the impact of the target in the rows on the target in the column.

Retailer	Policy	Reduction Target in policy / % (see Table 2)	UKPP				C2030 (food waste only)
			T1	T2	T3	T4	
Tesco	Plastic	50% (All Packaging)	3	3	2	2	0
	Food Waste	n/a	-1	-1	-1	0	3
Sainsbury's	Plastic	50% (Plastic)	3	3	2	2	0
	Food Waste	50%	-1	-1	-1	0	3
ASDA	Plastic	3 billion pieces	3	3	2	3	0
	Food Waste	n/a	-1	-1	-1	0	3
Morrisons	Plastic	50% (Plastic)	3	3	3	3	0
	Food Waste	50%	-1	-1	-1	0	3
Aldi	Plastic	50% (All Packaging)	3	3	2	2	0
	Food Waste	50%	-1	-1	-1	0	3
M&S	Plastic	30% (Plastic)	3	3	2	3	0
	Food Waste	50%	-1	-1	-1	0	3
Co-op	Plastic	15% (Plastic)	3	3	2	3	0
	Food Waste	50%	-1	-1	-1	0	3
Lidl	Plastic	40% (All Packaging 25%)	3	3	2	2	0
	Food Waste	50% (in-store)	-1	-1	-1	0	3
Iceland	Plastic	100% (Plastic)	3	3	2	0	0
	Food Waste	50%	-1	-1	-1	0	3
Waitrose	Plastic	50% (Plastic)	3	3	2	1	0
	Food Waste	50% (operational)	-1	-1	-1	0	3
Ocado	Plastic	n/a	1	1	1	1	0
	Food Waste	100% (operational)	-1	-1	-1	0	3

Table 3b – (in) Coherence Analysis of the Retailers' policy as related to ambitions of the UK Plastics Pact, and Courtauld Commitment. using the framework from (Nilsson et al., 2012) and (Nilsson et al., 2018) Target 1, T1 is the elimination of 13 unnecessary items, PVC and EPS, T2 is for 100% of plastic packaging to be reusable, recyclable or compostable, T3 is for 70% of plastics to be effectively recycled or composted, T4 is for plastic packaging to contain 30% average recycled content.

Interaction label		Meaning
+3	Indivisible	Progress on one target automatically delivers progress on another
+2	Reinforcing	Progress on one target makes it easier to make progress on another
+1	Enabling	Progress on one target creates conditions that enable progress on another
+/- 0	Consistent	There is no significant link between the two target's progress
-1	Constraining	Progress on one target constrains the options for how to deliver on another
-2	Counteracting	Progress on one target makes more difficult to make progress on another
-3	Cancelling	Progress on one target automatically leads to a negative target on another

Table 3c – coding framework for coherence analyses in tables 3a and 3b ref Nilsson et al

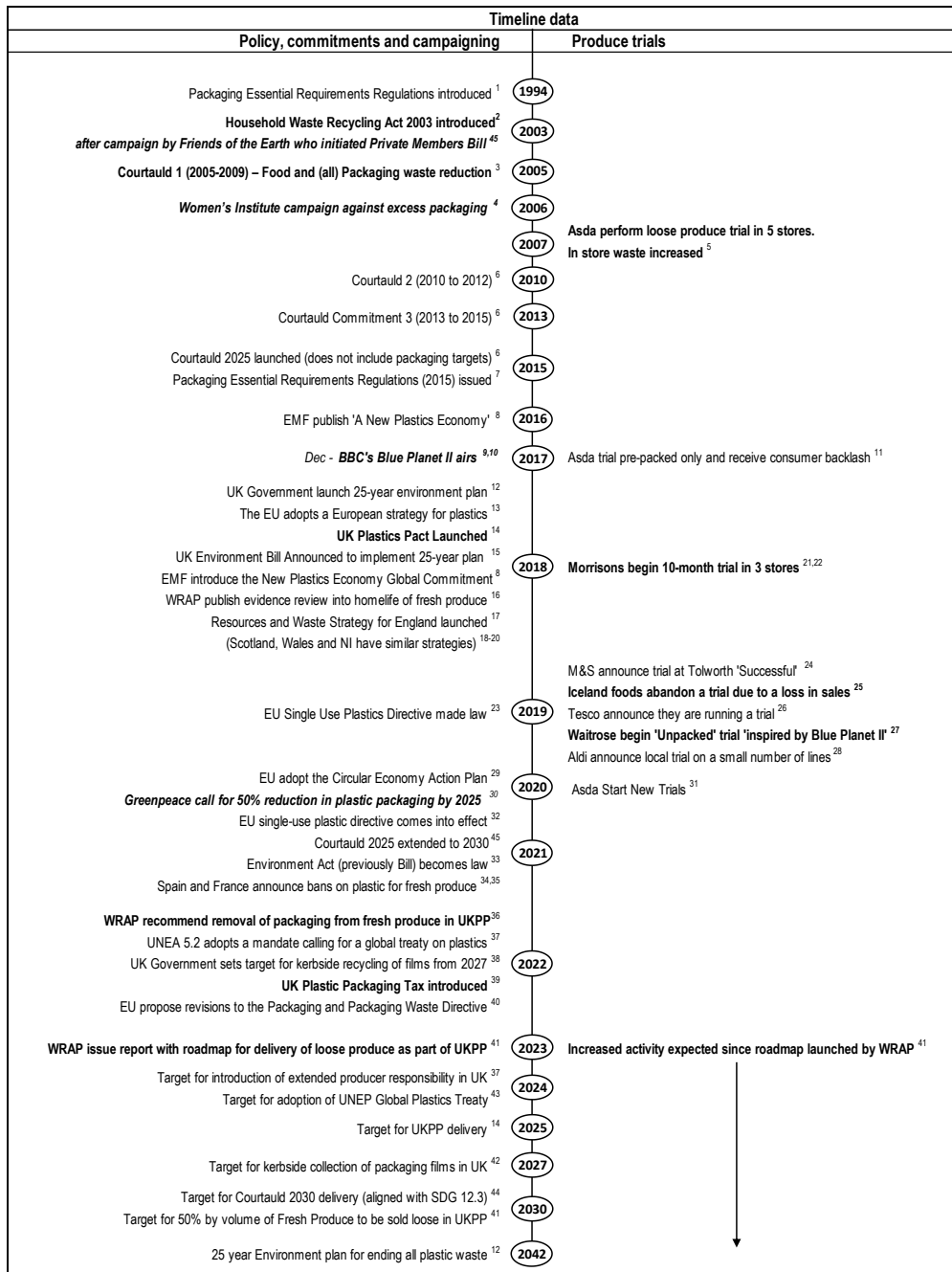


Figure 1 showing time-line of relevant UK and EU legislation, voluntary agreements and high-profile environmental campaigns along with the dates of loose produce trials reported by retailers

¹(European Union, 1994), ²(UK Government, 2003), ³(WRAP, 2022a), ⁴(Poulter, 2006), ⁵(Packaging News, 2007), ⁷(legislation.gov.uk, 2015a), ⁸(EMF, 2018), ^{9,10}(BBC, 2017; Gell, 2019), ¹¹(Paterson, 2017), ¹²(gov.uk, 2018b), ¹³(European Commission, 2022a), ¹⁴(WRAP, 2018), ¹⁵(Harvey, 2021), ¹⁶(White and Stanmore, 2018), ¹⁷⁻²⁰(gov.uk, 2018a; Scottish Government, 2016; UK Governments, 2020; Welsh Government, 2021), ^{21,22}(Perkins, 2021; WRAP, 2021), ²³(European Commission, 2019), ²⁴(M&S, 2019), ²⁵(Barrie, 2019), ²⁶(Edie.net, 2019), ²⁷(John Lewis Partnership, 2021), ²⁸(Wells, 2019), ²⁹(European Commission, 2020), ³⁰(Greenpeace, 2020), ³¹(Asda, 2020), ³²(European Commission, 2019), ³³(gov.uk, 2021), ^{34,35}(French Government, 2021; Spanish Government, 2021), ³⁶(WRAP, 2022f) ³⁷(UNEP, 2022), ³⁸(DEFRA, 2022), ³⁹(HM Revenue and Customs, 2022), ⁴⁰(European Commission, 2022b), ⁴¹(Conroy, 2023), ⁴⁴(WRAP, 2022b), ⁴⁵(Friends of the Earth, 2016)

Appendix B – Legislation relating to plastic packaging and food waste in the UK

The most significant legislation relating to plastic packaging in the UK currently is the Packaging Essential Requirements regulations (PER) (legislation.gov.uk, 2015) and the Producer Responsibility Regulations (Packaging Waste) (legislation.gov.uk, 2007) which both originate from the EU's Packaging Essential Requirement Regulations of 1994 (European Union, 1994).

The former sets out what is acceptable under law for the composition of packaging materials (e.g. the exclusion of heavy metals, ensuring that materials are recyclable or recoverable) and the latter obliges companies be (partially) responsible for the recycling of the packaging they place on the market in order for country-wide recycling targets to be set, originally via the EU and now through the Resources and Waste Strategy (Verghese et al., 2013).

Significantly, the PER regulations state that packaging should be designed ‘... that the packaging volume and weight is limited to the minimum adequate amount to maintain the necessary level of safety, hygiene and acceptance for the packed product and for the consumer.’ (legislation.gov.uk, 2015), ‘and for the consumer’ allowing, for example, for the producer to provide extra packaging functionality that will appeal to their customers that might use extra material (e.g. a reseal strip).

These laws are no longer seen as fit for purpose as household recycling rates have plateaued, so legislation is currently being updated both in the EU and the UK. In 2018 the EU adopted a European Strategy for plastics (European Commission, 2022a) and the UK Government launched both its 25-year environment plan (gov.uk, 2018b) and the Resources and Waste Strategy for England (gov.uk, 2018b). Equivalent strategies exist or are in development for all UK nations (Scottish Government, 2016; UK Governments, 2020; Welsh Government, 2021). Following the announcement of the 25-year environment plan, consultations have subsequently taken place on several proposed regulations which would help the drive towards a circular economy. These include a plastics packaging tax (implemented in April 2022) (HM Revenue and Customs, 2022), a deposit return scheme (DRS) for drinks bottles, Extended Producer Responsibility (‘the producer pays’), an overhaul of the producer responsibility regulations (DEFRA, 2022), standards for bio-based, biodegradable and compostable plastics, and consistent collection of waste packaging from households across the UK. The 25-year plan has the specific target of ending all avoidable plastic waste by 2042.

The UK Environment Bill was announced in 2018 to replace EU environmental legislation post-Brexit and as a vehicle to implement the 25-year plan (Harvey, 2021), becoming law as

the Environment Act in Nov 2021 (gov.uk, 2021). In March 2022, the United Nations Environment Assembly (UNEA-5) adopted a mandate calling for the development of a global treaty on plastics with a target for adoption of 2024 (UNEP, 2022) and in November 2022 the EU issued a draft update of the 1994 Packaging and packaging Waste Directive (EU, 1994; European Parliament, 2022)

Appendix C - Discussion of other solutions to loose fruit and vegetable packaging

C.1 Lightweighting (Reduction)

Reduction, including removal of unnecessary components, and light-weighting has been a focus since the first of the Courtauld commitments (WRAP, 2022a). In addition to the plastics pact targets, most retailers have also set out their intention to reduce the total amount of plastic and/or packaging they use. Five of the ten retailers investigated in this study have set out the intention of reducing their plastic packaging (or all packaging) by 50% by 2025 (see Table 2 and Supplementary Information 1a). This target does not feature in the UKPP or the 25-year environment plan. However, it does appear in a Greenpeace report (Greenpeace, 2020) which called for this to be a target in the Environment Bill, and in 2022 there was an attempt to get this target introduced into legislation through a private members bill (UK Parliament, 2022). It is possible that the frequent occurrence of the same target in supermarket documents is because of this wider lobbying context.

C.2 Reusable

The introduction of reusable packaging systems has the potential to significantly reduce waste from single-use plastic packaging (Greenwood et al., 2021). However the number of consumer products currently sold in reusable packaging is estimated to be less than two per cent (George, 2020). In the fresh produce sector reusable business-to-business packaging is already well utilised – evidenced in the store audit with two of the three retailers using returnable crates. The sale of loose produce, encouraging customers to use their own reusable bags can be considered as a form of Refill. Providing the more complex ‘Return’ systems, where a reusable pack is returned by the consumer, washed and used again is an ambitious task, and there is still much research to be done in this area (Accorsi et al., 2022). Complicated by the breadth and complexity of the produce supply chain, it would make sense for retailers to investigate other categories first.

C.3 Recyclable

Recyclability is a key area in all of the retailers' policies. There has been a distinct effort to eliminate the less recyclable plastics, rigid PVC and Polystyrene, as per UKPP target 1, and also black plastic (covered by target 2). Otherwise widely recycled plastics made from e.g. PET but with a black pigment cannot be detected by Infrared sensors in automated sorting processes (unless an IR-detectable additive has been used) and will end up in the residual waste (POST, 2019). The results of the store audit support this – virtually no black plastic trays were observed. This reduced selection of materials for rigids (mainly PET and PP) means that in theory, most rigid plastics used in the produce sector are now recyclable (whether they are collected by individual local authorities is another matter). However, there is still a way to go before Pots, Tubs and Trays can be 100% closed-loop recycled - PET is the most widely recycled plastic in the UK, thanks to the relatively mature bottle recycling process but PET trays are not suitable for the bottle recycling process (RECOUP, 2021). PP cannot currently be recycled into material for food contact applications (Recycling Magazine, 2021).

Flexibles – i.e. films and bags, have had very low recycling rates to date - only 7% was collected in the UK 2019 (RECOUP, 2019). Progress is, however, being made. In 2021 in-store collection points for 'soft' plastics in store became widespread (The Co-operative, 2021; White, 2021) and kerbside collection is due to be introduced in 2027 (DEFRA, 2022). However, collection is only part of the solution, and improvements in sorting and processing need to be made alongside the development of end markets for the recycled material. This is being addressed through initiatives such as CEFLEX (CEFLEX, 2022). If these succeed, then there is no reason why produce packaging cannot eventually be 100% recyclable (but unlikely within the timeframe of the UK Plastics Pact).

C.4 Compostable

Compostable plastics are a subset of biodegradable plastics which break down safely into water, biomass and gases under specific conditions (Purkiss et al., 2022). To qualify as 'compostable' materials have to be certified as either industrially (BSI, 2000) or home compostable (TUV Austria, 2019). Industrially compostable plastics will not necessarily home-compost as the processing temperatures are higher. As with Reuse, compostable plastics are currently niche; just 8,000 tonnes were used for packaging in the UK in 2018 (Ricardo Energy & Environment, 2019) and in 4.2.1 it has been shown that retailers have no targets of their own for the introduction of compostable materials. There are a number of potential reasons for this, including the lack of national targets and the lack of collection sorting and processing

infrastructure for industrial processing (UCL Plastic Waste Innovation Hub, 2020) and that only a minority of UK citizens home-compost (UCL Plastic Waste Innovation Hub, 2022). There is also the added complication that compostable films could contaminate the nascent flexible plastics recycling stream (see 4.3.3), e.g. the Co-operative do not accept compostables in their ‘soft plastics’ recycling scheme (The Co-operative, 2023). There is an obvious advantage to the introduction of compostable labels for loose produce with a peel that will end up in food composting, but without an established waste stream to deal with the waste packaging, retailers appear reluctant to investigate other packaging components. Once food waste collection has been made available to all households in the UK, originally due in 2023 (HM Government, 2021), this may be reviewed. The inconsistency in food waste collection highlights that the collection and recycling of plastics is not the only sector of the UK with less than perfect harmonisation between local government authorities.

C.5 Recycled content

To be as circular as possible, plastic packaging should also have some recycled content (an average of 30% target for the UKPP). PET and HDPE are available in food contact grades, but PP only in trial quantities (Recycling Magazine, 2021) and LDPE only from chemical recycling which is more energy intensive than mechanical recycling (Hyslop, 2021). The Plastics Packaging Tax introduced on 1st April 2022 may help to drive this – plastic packaging which does not contain a minimum of 30% recycled content is now liable to a tax with an initial charge of £200 per tonne (HM Revenue and Customs, 2022). It should be noted, however, that supply for recycled plastic is already outpacing demand (O’Connell and Kumar, 2021), an increase in recycling infrastructure in the UK will be required for UKPP signatories to fulfil their commitments (Moore, 2020).

C.6 Optimisation of pack sizes and added packaging functionality

Where packaging has been shown to be necessary, for shelf life or consumer acceptability, there is an opportunity to optimise pack sizes, or consider other packaging features, e.g. barrier coatings, resealability or improved product use instructions in order to prevent food waste in the home. For example (Williams et al., 2020) identified packaging size and detailed information of food safety and storage as important factors in reducing food wastage. Making pack sizes smaller or, for example, adding a reseal-strip have the potential to reduce this food waste but may increase the amount of packaging material used. However, with some exceptions, the embedded carbon in food packaging is typically a fraction of that of the product is protecting

(Heller et al., 2019; INCPEN, 2009). This presents the opportunity to study the trade-off between food and packaging waste at a household level. The WRAP report used to evidence selling uncut fresh produce loose used Discrete Event Simulation to model household consumption, the Household Simulation Model, HHSM (Kandemir et al., 2020). The relationship between household food waste and packaging has been studied previously by (Williams and Wikström, 2011) and also (Verghese et al., 2018). The HHSM model is now being adapted to incorporate packaging variables in order to assess food waste vs packaging waste for different scenarios.

Supplementary Information

S1 a),b) and c) - *Fresh produce on the loose detailed retailer policy and trial spreadsheets and table, OSF.*

S2 - *Fresh produce on the loose - saved internet searches for packaging and food waste policies*

S3 - *Fresh produce on the loose - downloaded webpages and documents, OSF.*

All can be found at

https://osf.io/m72un/?view_only=17af492cbe1c4280b33f5e188a13051a