HM Government

Standards for bio-based, biodegradable, and compostable plastics

Summary of responses to the call for evidence and Government Response.

April 2021

Any enquiries regarding this publication should be sent to us at:
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Foreword

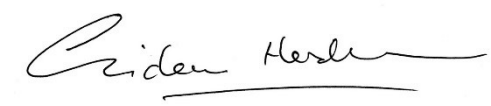
Plastic is ubiquitous in modern day life. It's in the insulation in our homes; in our vehicles and electronics; and almost half of all plastic placed on the market each year goes into packaging.

The Covid-19 pandemic has further underlined the important, sometimes vital, role that plastic plays in many applications, for example, personal protective equipment. In these cases, and many others, plastic is a highly valuable resource. However, the UN Environment Programme estimates that only 9% of all plastic waste ever produced has been recycled, about 12% has been incinerated, whilst the remaining 79% has accumulated in landfills, dumps, or the natural environment. New research and discoveries are published routinely documenting the unprecedented damage plastic waste is having on the environment.

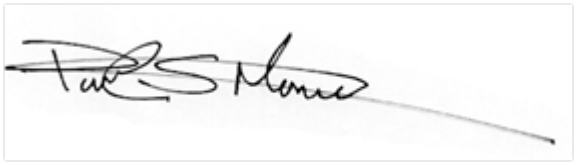
Urgent action is required to stop plastic waste from finding its way into the natural world. We need to keep material in use for as long as possible, in line with our ambitions to transition to a circular economy. The Resources and Waste Strategy sets out how the government will seek to increase the amount of plastic we recycle; encourage the design of plastic products which can be reused over and over again; and eliminate unnecessary uses of plastic, particularly in single-use products.

Innovation will be vital in our efforts to tackle plastic pollution and climate change together. Whilst the bioeconomy is already a large part of the UK economy, supporting key industries and generating significant economic impact, the ambition from the Bioeconomy Strategy is to double the size of the bioeconomy by 2030. The development of bio-based plastics, those made from organic sources such as food waste, could be a key part of this, and reduce our reliance on fossil fuels. Where the infrastructure required is in place, compostable plastics also have the potential to ensure less food waste ends up in landfill where it can emit powerful greenhouse gases.

It is essential, however, that the right evidence is gathered to ensure that the solutions we chose today do not cause greater complications for tomorrow. For that, we are extremely grateful to everyone who submitted responses to this call for evidence. These will help government assess the role and effectiveness of standards and craft an evidence-based, consistent, and effective policy framework to ensure best use of this valuable material. The UK Plastics Pact, launched in 2018, has been a strong driver for progress, and we will continue to support this and similar initiatives which bring industry together to improve resource efficiency and reduce environmental damage. The challenges that are posed by plastic waste require the entire supply chain to come together to ensure the most effective system for people and the environment.



Professor Gideon Henderson, Chief Scientific Adviser, Department for Environment, Food and Rural Affairs



Professor Paul Monks, Chief Scientific Adviser, Department for Business, Energy and Industrial Strategy

April 2021

Executive summary

The government is committed to being a world-leader in tackling plastic pollution, which has emerged as a major environmental challenge.

We will do this by delivering on the plan outlined in *Our Waste, Our Resources: A Strategy for England*, published in December 2018, which sets out how we will minimise waste by moving towards a more circular economy. Bio-based, biodegradable and compostable plastics are of interest as a potential solution to some of the issues caused by plastic waste. They could also be one of the ways in which we support delivery of *Growing the Bioeconomy: a Strategy to 2030,* published in December 2018. This Strategy sets out our plans to harness the power of bioscience and biotechnology and develop a world-class UK Bioeconomy.

In adopting these new, innovative types of plastic, however, we must ensure that they are more sustainable than other alternatives. That is why Defra and BEIS published a call for evidence on the demand, benefit, and implications of developing standards for bio-based, biodegradable, and compostable plastics. This document sets out a summary of responses to that call for evidence and outlines the government response. We are grateful for the evidence received so far and continue to welcome further evidence in this area.

Definitions

Bio-based – These are plastics that are made using polymers derived from plant-based sources such as starch, cellulose, or lignin. Bio-based plastics can be engineered to be biodegradable, but are not necessarily.

Biodegradable – These are plastics that can be broken down into water, biomass, and gases such as carbon dioxide and methane. Biodegradability depends on environmental conditions such as temperature, humidity, microorganisms present, and oxygen.

Compostable – Compostable plastics are a subset of biodegradable plastics that break down into water, biomass, and gases under composting conditions. Industrial composting conditions are the most optimal: temperatures of 55-70 degrees C, high humidity, and oxygen.

Key findings

Responses were mixed regarding the potential contribution of bio-based plastics to a more circular economy, with positive views regarding their potential carbon impact (in comparison to conventional alternatives) contrasting with more cautious views regarding their potential impacts on both land-use and the existing waste management system.

There was more consensus on biodegradable plastics, with the majority view being that they have a limited but nonetheless valid role, primarily in applications where conventional plastic is

typically too contaminated to be reused or recycled. Repeated and strong concerns were raised, however, regarding the extent to which plastics marketed as biodegradable actually biodegrade in the open environment, and whether the use of biodegradable plastics could encourage littering if citizens consider them to be in some way environmentally-friendly.

Similar issues were raised in relation to compostable plastics, albeit with recognition that, unlike biodegradable plastics more broadly, there is a recognised standard that plastics suitable for industrial composting (but not home composting) should achieve. As with biodegradable plastics, the consensus was that compostable plastics should only be encouraged in very specific circumstances.

There was a clear consensus in relation to plastics containing prodegradant agents aimed at aiding the biodegradation process (typically referred to as oxo-degradable or oxo-biodegradable plastics), which was that such technologies are unproven and likely to be a source of microplastic pollution.

In regard to product labelling, evidence suggests that plastics should not be labelled as ‘bio-plastics’ as the term is ambiguous and offers little value to the public. Responses tended to focus on the need for labelling to be clear and provide guidance on how to dispose of products alongside whether they are bio-based and/or biodegradable. Such clarity would also bring benefits in waste management through helping ensure different materials are sorted correctly.

Forward look

The evidence base is clearly still developing in relation to these new types of plastic, particularly in terms of their environmental impacts in comparison to alternatives. In accordance with the waste hierarchy, our current preference remains that most plastics are reusable or recyclable. We recognise though that in some applications and specific circumstances biodegradable/compostable plastics may be more suitable. We recommend that businesses consult available guidance and evidence summaries on these plastics when considering using them to help assess if this the case.

We welcome further research on the full environmental impacts of using bio-based plastics, particularly bio-based plastics derived from material that would otherwise have been waste. We also welcome further evidence on the development and application of robust standards for biodegradability which are proven to apply outside of laboratory conditions.

We are taking forward a number of policy proposals informed by the evidence received in response to this call. This includes further consultations on extended producer responsibility for packaging and consistent recycling collections. The responses will also inform future policies aimed at tackling single-use plastic and the application of HMT’s plastic packaging tax. We are also minded to introduce a ban on oxo-degradable plastics, subject to further evidence and a public consultation.

Chapter 1 – Introduction

Introduction

1.1 The UK is a world leader in tackling plastic pollution, and we have committed to work towards all plastic packaging placed on the market being recyclable, reusable or compostable by 2025 and to eliminate avoidable plastic waste by 2042.

1.2 Bio-based, biodegradable, and compostable plastics are of increasing interest as a potential solution to some of the issues caused by plastic waste. The government is concerned, however, that without robust standards or certification criteria, claims about the benefits that such materials may bring cannot be verified and uncertainty about unintended consequences will remain.

1.3 The government published *Growing the Bioeconomy: A National Bioeconomy Strategy to 2030* in December 2018, setting out a collective approach from across government, industry, and the research community to transform the UK economy through the power of bioscience and biotechnology. In this, we committed to work with UK Research and Innovation (UKRI) and industry to seek evidence on the demand, benefits, and implications of standards for bio-based and biodegradable plastics.

1.4 *Our Waste, Our Resources: A Strategy for England*, published in December 2018, reiterated this commitment. The approach is also intended to support the objectives of other key government initiatives including the *25 Year Environment Plan* and *Industrial Strategy.*

1.5 In 2019, BEIS and Defra published a "Call for Evidence" in relation to standards for bio-based, biodegradable and compostable plastics. In this, we sought evidence to identify gaps and to provide expert advice on:

- The overall sustainability of bio-based and biodegradable plastic products, particularly when compared with those made from fossil-fuel based sources. This included all aspects of a product's life-cycle to assess whether technical standards or other related options are suitable mechanisms to add value for such products;
- Existing relevant plastic degradation standards and how, or if, they might be promoted without any adverse effects to the environment and disposal routes, and;
- The design and implementation of standards for biodegradable plastics to ensure that they fully biodegrade in a reasonable timeframe in specified environments.

1.6 This document sets out a summary of responses to the call for evidence and highlights areas of interest that we will consider further. The government is grateful for the submitted evidence, which will inform future policy development.

Engagement with the call for evidence

1.7 There were 85 responses to the call for evidence which covered a wide range of interests including from environmental campaigners, local government authorities, academic institutions, bio-based and biodegradable plastic manufacturers, plastic

product producers and users, waste management companies and standards development and certification/compliance bodies.

1.8 We received a wide set of responses to each of the questions, which is to be expected given the complexity of the topic and the presence of important knowledge gaps in this field. We have therefore provided a high-level summary of the responses, which in many cases is not quantitative, as answers were not directly comparable.

Defining and assessing the responses

1.9 Many responses to the call for evidence cross-referenced multiple questions and there was significant overlap in the answers. We have therefore analysed the responses by grouping questions into themes.

Table of themes

Theme	Questions
Circular Economy	1, 6
Biodegradation	7, 9, 10, 11, 14, 15, 16, 17, 18, 19, 20, 21
Environmental Impact	2, 3, 8, 12, 13
Labelling and Certification	22, 23, 24
Impacts on the Waste Industry	26, 27, 28, 29, 30
Market Factors	4, 21, 25
Other Issues Raised	5, 13, 31

Figure 1. A Table reorganising the questions from the Call for evidence into "Themes"

1.10 We have defined the three key types of plastic this call for evidence as follows:

- **Bio-based** – These are plastics which are made using polymers derived from plant-based sources such as starch, cellulose, or lignin. Bio-based plastics can be engineered to be biodegradable, but are not necessarily.
- **Biodegradable** – These are plastics which can be broken down into water, biomass, and gases such as carbon dioxide and methane. Biodegradability depends on environmental conditions such as temperature, humidity, microorganisms present, and oxygen.

- **Compostable** – Compostable plastics are a subset of biodegradable plastics that break down into water, biomass, and gases under composting conditions. Industrial composting conditions are the most optimal: temperatures of 55-70 degrees Cº, high humidity, and oxygen. Materials that break down in industrial composters may not break down under home composting conditions.

1.11 Whilst there are important differences between these three categories, some plastics might fall into a combination of these categories as they are not mutually exclusive. Due to this overlap, the term 'Bioplastics' is often used as a simple, catch-all term to refer to both bio-based and biodegradable plastics. As you can see in Figure 2, however, 'Bioplastics' can cover a large variety of significantly different plastic materials which can often make the term confusing and unhelpful.

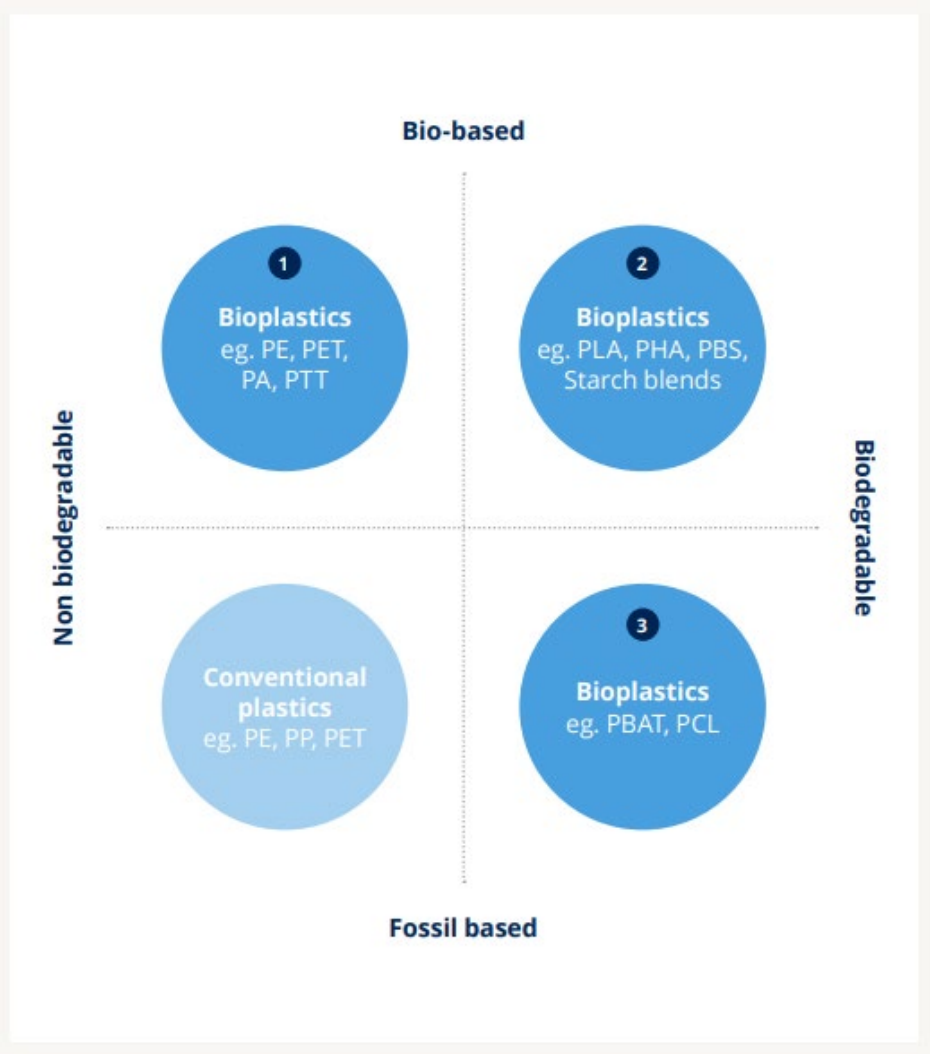


Figure 2. A bubble chart illustrating the differences and overlaps between different types of plastics. This image is from 'Understanding plastic packaging and the language we use to describe it' (WRAP, 2019).

Chapter 2 – Circular economy

Question 1 – The government has made clear that we want to eliminate all avoidable plastic waste and to move toward a more circular economy. What role, if any, is there for bio-based plastics to play in achieving the outcomes below? How could the circularity of these materials be reflected or measured? What is the evidence in support of your view?

- Clean Growth, including growing the Bioeconomy
- Circular economy
- Environmental protection
- Citizen clarity

Question 6 – The government has made clear that we want to eliminate all avoidable plastic waste and to move toward a more circular economy. What role, if any, is there for biodegradable plastics to play in achieving the outcomes below? How could the circularity of these materials be reflected or measured? What is the evidence in support of your view?

- Clean Growth, including growing the Bioeconomy
- Circular economy
- Environmental protection
- Citizen clarity

Summary of responses

2.1 The responses in respect of the role of bio-based plastics in the circular economy were mixed, from suggesting that there was no role at all to there being a large one. Some respondents argued that bio-based plastics that are chemically the same or similar to recyclable fossil fuel-based plastics could contribute more to a circular economy by acting as a renewable source for the production of such plastics.

2.2 Most responses stated that there is a limited role, if any, for biodegradable and compostable plastics in the circular economy as these are likely to be single-use and/or to have a short lifespan. However, other respondents asserted that returning materials to land, as part of compost or digestate, represented a valid circular economy route. Some questions were raised regarding the nutritional value added by these kinds of plastic and more investigation is required to clarify this.

2.3 In the responses there was little hard evidence presented from lifecycle assessment (LCA) studies to illustrate the contribution that bio-based and biodegradable plastics could make in a more circular economy, although several studies were referred to.

2.4 The general view was that greenhouse gas (GHG) emissions were reduced from the production and use of bio-based plastics when compared to conventional plastics. Some

responses, however, raised concerns that the full environmental impacts of bio-based plastics, including land and water usage for example, were potentially greater overall compared with conventional based plastics.

2.5 Other responses stated that environmental impacts were of a lower concern in comparison to the practicalities and issues associated with the effective introduction and management of bio-based and biodegradable plastics into current and future waste management systems.

Government response

2.6 The government is committed to tackling the issue of plastic pollution and will continue to explore all policy options to reduce the impact of plastic in the environment. We welcome the development of truly biodegradable plastics that do not have any adverse effects on the environment. These need to be materials that degrade in a reasonable time frame and do not leave any trace of microplastics in the soil and the ocean. When disposed of, such materials would also need to not be damaging to the recycling system. The use of these materials would need to fit into our wider circular economy goals, where we prioritise reuse and prevention, but we acknowledge that truly biodegradable materials would be beneficial in some niche applications.

2.7 More research, however, is required to fully understand whether in practise biodegradable plastics do not simply accelerate the fragmentation of plastic into microplastic.

2.8 For new polymers, whether bio-based, biodegradable, or otherwise, it is important that there are appropriate end-destinations for recycling, clear labelling, and accessible guidance available to the public and industry.

2.9 Further research is required to better understand the trade-offs and environmental impacts associated with generating the feedstocks for bio-based plastics. On the basis of current information, a key area of interest for the government is bio-based plastics derived from materials that would otherwise have been waste. We welcome further research on the full environmental impacts of bio-based plastics, including in terms of (but not limited to) carbon emissions.

2.10 The government will work with UKRI and industry to obtain more evidence in order to explore these important issues further.

Chapter 3 – Biodegradation

Biodegradation standards

Question 10 - What testing regimes/methodologies are you aware of that could verify that biodegradable plastics completely degrade (breaking down to just water, biomass, and gases, such as carbon dioxide or methane) in the open environment instead of simply fragmenting into microplastics? If not, what are the key challenges to establishing such a test?

Question 11 - Would such testing regimes/methodologies be applicable to plastics which contain prodegradant agents intended to aid the biodegradation process? We are particularly interested in any evidence established in the last three years.

Question 17 - A list of currently active biodegradability standards and test methods for all plastic materials in soil, marine and wastewater environments is included in the report 'A Review of Standards for Biodegradable Plastics'. Are there other relevant standards or test methods for those circumstances that you are aware of that do not appear on this list?

Summary of responses

3.1 The responses indicated that there are few standard tests which apply directly to the open environment. There was a broad agreement that laboratory tests do not accurately predict how plastics biodegrade in natural environments.

3.2 Many responses also raised concerns that laboratory tests based on gas production or consumption would not evaluate the impact of any residues from the plastic, such as microplastic, on the environment.

3.3 With respect to plastics that have prodegradants added to them, which are substances added to a plastic in order to speed up or aid degradation and are often called oxo-degradable and oxo-biodegradable plastics, the majority of respondents from a range of stakeholders objected to their use, and many supported introducing a ban.

3.4 These respondents expressed the view that plastics containing prodegradant agents pose an environmental risk as they result in more fragmentation of plastics into microplastics and that there is little evidence that they biodegrade fully.

3.5 Some responses, however, primarily from producers who make such plastics, asserted that prodegradants can promote biodegradation and that such products can be accurately tested with existing biodegradation tests. Some producers distinguished between oxo-degradable plastic and oxo-biodegradable, where the former simply accelerates fragmentation whereas the latter is specifically engineered to become biodegradable after fragmentation under the right conditions.

3.6 In addition to the standards and test methods listed in the review from IBioIC published alongside the call for evidence, the responses mentioned many other standard biodegradation methods which are largely standard laboratory methods that seek to imitate biodegradability in a variety of situations and environments (see Annex A).

3.7 Many respondents mentioned that the majority of the tests for biodegradable and non-biodegradable plastics are largely laboratory based, although many use different media

such as soils, water, and compost. Some of the tests are for specific products such as mulch, plastic film, and packaging material. This suggests that no single test would fit all types of environments and applications and testing needs to be specific to the product.

Biodegradation times in the environment

Question 7 - With existing technology and materials, what would be the minimum timeframe for complete biodegradation (breaking down to nothing but water, biomass, and gases, such as carbon dioxide or methane) for plastics designed to biodegrade? We would particularly welcome an assessment in the following environments: Deep Sea; Surface of the Sea; Freshwater; Beach; Soil – surface; Soil – lightly buried; Landfill; Industrial composting; Home composting.

Question 9 - To what extent, if at all, can the existing evidence be used to extrapolate the degradation rate of plastics in different environments (e.g. in surface water vs deep sea, etc.)?

Summary of responses

3.8 The responses were limited in terms of providing current minimum biodegradation times in different environments for biodegradable plastics already on the market. Some responses suggested that for composting environments anything from a period of 6 weeks to 12 months might apply. Degradation times in other environments were indicated from as little as 28 days to up to 4 years or more.

3.9 Most responses, however, asserted that it was not possible to provide such a quantified response as so many factors contribute to the decomposition rate. In terms of the rate in different environments, biodegradation was generally considered likely to occur most rapidly in a composting environment and most slowly, if at all, in the open ocean.

3.10 One response referred to standards in development which they believed would be applicable for home composting situations. Other responses stressed that any new standards must take into consideration the many variations in home composting environments and queried whether a single standard could cover all these sufficiently.

3.11 Many responders warned that extrapolation from standard laboratory tests was not acceptable and is not permitted within existing standards. The general view was that the conditions in different natural habitats vary considerably and it is not possible yet to compare performance in the environment with laboratory tests.

3.12 There were suggestions of studies attempting to derive correlations from lab and field studies. Whilst some studies were indicated; the consensus was that more work in this area is required.

Industrial and home composting

Question 14 - What evidence, if any, is available regarding the suitability of the existing industrial and home composting standards? We welcome any suggestions on how these standards could be adapted to current and future needs, if necessary.

Question 15 - To what extent, if at all, would a home composting standard that covers all home composting techniques, equipment and environments in the UK be possible? If so, would it be a desirable system to adopt?

Question 16 - What potential unintended consequences could arise as a result of a growth in use of compostable plastics?

Summary of responses

3.13 Many responses stated that composting standards and/or their related testing procedures were not suitable for both industrial and home composting. They stated that the preparation of material for laboratory testing and the use of optimal testing conditions means that there is little correlation between current laboratory tests and performance in actual composting conditions.

3.14 Responses stated that timescales for industrial composting are often shorter and not necessarily aligned with the parameters set in current standards. It was argued that compostable plastics are therefore unlikely to completely decompose within facilities, and therefore some plastic residues would remain in the compost. Therefore, there is some worry that compost and digestate could be contaminated by plastics which would then be spread to land outside of the conditions they require to fully degrade.

3.15 Some responses stated that the appearance of many compostable plastics is similar to conventional plastics and that this could be an additional source of confusion for both the public and waste operators when sorting waste.

3.16 The standard EN13432 was cited as the main composting standard, which does include some controls to protect the quality of composts. It includes a limit on small plastic particles (no more than 10% of the initial plastic mass being present as plastic particles >2 mm). Some respondents expressed the view that the limit was not stringent enough. A repeated concern was that widespread uptake of these materials could lead to significant contamination of compost/digestate.

3.17 Many responses queried whether any standard would give industrial composters sufficient confidence in the biodegradability of plastic material they receive. These responses tended to view the presence of plastics, of any type, as undesirable in industrial plants. A key consideration for these facilities is producing quality compost in accordance with PAS100 (Publicly Available Specification for Composted Materials) which has limits on plastic contamination.

Remaining questions in this theme

Q18. What areas, if any, would require improvement in existing standards to strengthen their effectiveness? To what extent, if at all, would the development of new standards for biodegradability constitute a viable alternative? What is the evidence in support of your view?

Q19. When dealing with biodegradation, what are the advantages and disadvantages of producing standards? We would welcome your thoughts in relation to the production of standards at the following levels:

- *National*

- *Regional*
- *International*

Q20. Are you aware of any past or current work on a national, regional or international level to implement biodegradability standards?

Q21. To what extent, if at all, could biodegradability standards be beneficial for specific products (such as carrier bags) or product forms (for example those that with current technology are typically too contaminated to be mechanically recycled once disposed of)?

Summary of responses

3.18 Several suggestions were made in regard to how current standards could be improved. They focused predominantly on the need for standards to assess any residue which may be left behind as a result of degradation and its impacts on the natural environment.

3.19 There was a recurring theme in the responses that standards should be linked to a certification scheme rather just being a stand-alone entity. This would provide further assurance to both industry and the public that products have been tested and independently verified to comply with an existing standard.

3.20 A number of responses suggested that existing standards could be improved by ensuring that they define the extent to which plastic materials are allowed to be prepared (shredding/grinding) before conducting laboratory tests.

3.21 Some respondents also suggested that current composting standards should be revised to ensure they are aligned with current industrial composting processes.

3.22 Most respondents considered that standards should be at international and/or national level and that these should be aligned. There was little enthusiasm for regional standards (which was largely interpreted as intra-country by the respondents).

3.23 The responses indicate that most major standards development bodies already have an interest in and active working groups on standards for biodegradable plastics. Therefore, this appears to be an area of significant activity. Bodies indicated with active technical committees and working groups are:

- ISO – several committees including:
  - TC122
  - TC 61/SC 14/WG 2 on marine biodegradation of plastics
- ASTM - D20.96 sub-committee - Environmentally Degradable Plastics and Biobased Products
- CEN committees including
  - TC 249 Plastics developed standards about biobased plastics
  - TC 261 Packaging developed between 1994 and 2000 the standards for organic recycling of packaging
- BSI – exploring need for standards for the open environment
- REAL – (certify EN13432 in UK)

- NIST (USA)

3.24 There is currently no international or European standard for home composting. However, the responses indicate that there are several national regulations, standards and certifications: UNI 11183 (Italy), AS 5810 (Australian), NT T 51-800 (France), OK Compost (Belgium).

Government response

3.25 Responses were generally in agreement that laboratory tests are not representative of how plastics will behave in open environments, and that current tests rarely consider the environmental impact of residues from degradation, such as micro-plastics and other incomplete breakdown products, which could be of high concern if released to the environment. The government is therefore concerned that there are currently few standard tests which accurately represent how or if plastics will biodegrade in real-world environments.

3.26 This is a particular concern for home composting situations where conditions are more variable when compared to industrial composting. There is a need to better understand rates of degradation in home composting scenarios and the environmental impacts and any health implications from using compost containing partially-composted plastics, and we welcome further research on this.

3.27 In the Defra Review of standards for biodegradable plastic carrier bags published in December 2015, we stated that the government would continue to consider the technical specification for a genuinely biodegradable bag. This subsequent call for evidence outlines all the research available to inform current decision making on whether an exemption should be introduced for biodegradable bags. Based on the current evidence we will not be introducing any exemptions at this time and believe that reusable shopping bags should be promoted above all else. We will continue to review any future evidence, and welcome advancements in creating truly biodegradable single-use carrier bags.

3.28 The British Standards Institution (BSI) published a new standard on biodegradation of polyolefins in an open-air terrestrial environment (PAS 9017) in 2020. The aim of this new PAS is to provide a standard specification that provides numerical data on the biodegradability of a given polyolefin containing a specific biodegradable additive under open-air terrestrial conditions. It's designed to simulate the overarching process of biodegradability in an unmanaged environment, as in the case of littering or unmanaged disposal. It does not provide data on how a polyolefinic material would perform under managed biodegradable end-of-life scenarios such as industrial or home composting, anaerobic digestion, nor organic recycling.

3.29 BSI are also running a project, BS EN 17427 Packaging: Requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations. Technical specifications and standards are an important step in ensuring that the materials we use behave as we expect and require them to. We will continue to monitor the extent to which these standards do, or do not, address the issues identified through this call for evidence, and will follow with interest any developments on PAS 9017.

3.30 On the subject of oxo-degradable and oxo-biodegradable plastics, on the basis of current evidence, including the review on oxo-degradable plastics conducted by our

Hazardous Substances Advisory Committee, there is insufficient evidence demonstrating that oxo-degradable/oxo-biodegradable plastics perform as claimed and biodegrade in a reasonable timeframe in the open environment. In the absence of further evidence, we are minded to introduce a ban on these materials, subject to a public consultation. We welcome the leadership on this issue shown by the UK Plastics Pact who have already committed to eliminate the use of oxo-degradable plastic.

Chapter 4 – Environmental impact

Q2. With regards to their environmental impact, and particularly greenhouse gas emissions, what quantitative evidence is available on the environmental impacts of producing bio-based plastics and managing them at end of life? How does the evidence compare to conventional fossil-based plastics?

Q3. If an accurate comparison between the environmental impacts of bio-based and conventional fossil-based plastics cannot be made at present, what barriers exist to making this comparison and what knowledge gaps would need to be addressed to enable us to do so?

Q8. What evidence is available of direct impacts of biodegradable waste plastics on biodiversity, ecosystems, and the natural environment in the short-term (over the degradation period of the item), and in the long term (including cumulative effects)?

Q12. What evidence, if any, is available to quantify the differing environmental impacts of compostable plastics when they "escape" and then degrade in the open environment?

Q13. The potential impacts of biodegradable plastics on waste processing are covered in Chapter 7. What other potential unintended consequences could arise as a result of a growth in use of biodegradable plastics?

Summary of responses

4.1 Many responses suggested that there were positive benefits to using bio-based plastics when compared with conventional fossil-fuel derived plastics in terms of greenhouse gas (GHG) emissions. In most cases this was from summarised findings, with few lifecycle assessment (LCA) studies provided. Many of the LCA studies referenced by respondents were carried out by bio-based plastic producers, with some being made available for verification by independent third parties.

4.2 Many respondents expressed caution when comparing different LCA assessments due to the variation of assumptions and boundaries used, and there was little discussion of the other potential direct environmental impacts of the use of bio-based plastics.

4.3 In terms of biodegradable plastics, concerns were raised regarding contamination of recycling streams, due to the difficulty of separating them from mechanically recyclable plastics. Some companies indicated they were undertaking eco-toxicity assessments when studying the degradation of their products in accordance with standards such as PAS100, EN13432, and AS4736. Little evidence was presented or cited with regard to the impact of biodegradable plastics in the open environment.

4.4 Litter, either as an escapee or deliberate, was frequently mentioned with concerns raised over how slowly littered biodegradable/compostable plastics might degrade in natural environments.

4.5 There was little evidence cited which described specific unintended environmental consequences arising from the use of biodegradable plastics. However, one key concern which was regularly discussed was whether, and if so to what extent, the use of biodegradable plastics could encourage littering. For example, if such plastics were perceived by the public to be in some way safer or more environmentally-friendly.

4.6 Responses also raised concerns that increasing the variety of plastics on the market without clear markings on disposal routes might lead to materials not being separated for the correct disposal route, such as recycling or composting, and either cross-contaminating those streams or being sent to landfill/incineration.

Government response

4.7 It is clear from this call for evidence that there is still a significant knowledge gap when it comes to the various trade-offs in generating feedstocks for bio-based plastic as well as the environmental impacts of biodegradable plastic.

4.8 Our priority in tackling plastic pollution is preventing it from entering the open environment in the first place. There is a strong concern from some parties that wider introduction of biodegradable plastics may be counter-productive to this aim. One study was cited by several respondents (UNEP, 2015) which highlighted concerns that an increase in litter could result from an increase in use of biodegradable plastics.

4.9 Whilst there are credible concerns regarding the overall sustainability of biodegradable plastics, we recognise that there appears to be a role for them to play in a more circular economy in some applications. More investigation is needed to clarify the environmental impact of these materials, especially if any residue is left by these plastics and any harm they may cause. We welcome further research in this area.

4.10 Through UKRI, we have supported and will continue to support research and innovation in plastics and we welcome the efforts of others in this field. More research and innovation is required to create truly biodegradable materials and subject to available funding we will continue to support industry and academia to achieve this goal whilst recognising that government's priority is to protect the environment, including by keeping materials in circulation for longer.

4.11 Biodegradable plastics have, so far, not been exempt from government policies aimed at reducing the use of single-use plastics, such as the ban on plastic straws, stirrers and cotton-buds. This will continue to be the default position, though this will be considered on a case-by-case basis as future policy is developed, including through public consultations and future calls for evidence.

4.12 In terms of compostable plastics, until the appropriate infrastructure is in place across the country to accept these materials, the government's preference is that they are used in closed loop systems with no reuse or recycle option available and with appropriate collection and disposal arrangements in place. We recommend that businesses consult available guidance and evidence summaries on this to help assess if this may be the case for their intended purpose. This includes the WRAP guidance, which we recommend is read in conjunction with the report by Eunomia on the Relevance of

biodegradable and compostable consumer plastic products and packaging in a circular economy.

Chapter 5 – Labelling and certification

Q22. What standards, labelling, and/or certification schemes are currently in place to determine the level of bio-based content in bio-based plastics?

Q23. To what extent, if at all, should current labelling requirements be changed to produce new suitable standards?

Q24. To what extent, if at all, should specific labelling rules apply to bio-based plastics to certify their proportion of bio-content – either to better inform consumers or for any other reason?

Q25. What evidence, if any, is available on the impacts that biodegradability certification and labelling systems may have on consumers' behaviour towards the disposal of items carrying such labels?

Summary of responses

5.1 Responses tended to focus more on labelling and certification for biodegradable plastics than for bio-based plastics.

5.2 There was an approximately even split between respondents that thought labelling for bio-based content would be beneficial and respondents that thought it would have a negative impact. Concerns were raised that additional information could be complex and difficult to understand with the potential for different terms to be misused by producers or misunderstood by consumers. Respondents queried, for example, whether labelling for bio-based content would prove confusing if they were mistakenly taken to refer to biodegradability.

5.3 Those that were aware of standards cited several for determining the bio-based content which are largely based on the oxygen or radiocarbon content. You can find a list of standards supplied to us in Annex A.

5.4 Certification schemes and bodies mentioned included the following (the credentials or relevance have not been validated):

- NEN (The Royal Netherlands Standardization Institute),
- TUV (Austria) – Bureau of Inspection & Certification (Pvt.) Ltd
- Bonsucro - Bonsucro is an international not for-profit, multi-stakeholder governance group established in 2008 to promote sustainable sugar cane.
- ISCC – International Sustainability and Carbon Certification
- RSB (Roundtable on Sustainable Biomaterials), [mentioned by others but also a respondent].

5.5 With respect to recommendations for labelling, the priority for most respondents was for labelling to be clear and simple for consumers. The majority of responses recognised that common terms such as biodegradable, compostable, renewable, and recyclable are

not always well-defined which is not helpful for the public without clear instructions for how to dispose of the products.

5.6 There was, as previously discussed, a high concern that the widespread adoption of labelling for biodegradability could promote littering of single-use items in expectation that such items would degrade effectively and safely in the open environment.

5.7 Some of the responses provided evidence on the impact that the labelling of biodegradable products could have on consumer behaviour. There was some concern that consumers are targeted with unfair claims of products having positive environmental credentials (so-called “greenwashing”).

5.8 Where evidence was given it tended to be about the impact that other labelling systems have had (e.g. eco-labelling). Little evidence was cited that specifically covers consumer behaviour with respect to biodegradability and many responses called for such evidence to be developed.

5.9 There were some responses which suggested stronger controls were needed to ensure that advertising claims are properly enforced and are not misleading.

5.10 One possible option mentioned by several respondents to assist the sorting process in both homes and sorting facilities would be to ensure that all biodegradable plastic items were a particular colour, or had a marker in them, which would allow for easy identification and separation.

Government response

5.11 In the 2019 consultation on reforming the UK packaging producer responsibility system, the government proposed mandatory labelling for packaging, to make it easier for consumers to know what packaging they can recycle. Biodegradable and compostable plastic packaging would be in scope of this. We are minded to take forward the proposal for mandatory labelling of packaging, subject to further analysis, legal considerations and the response to the second consultation on reforming the UK packaging producer responsibility system.

5.12 We understand that it is important for businesses to communicate with their customers and to ensure that work to improve the sustainability of their products is recognised. However, evidence suggests that plastics should not be labelled as ‘Bioplastics’ as the term is ambiguous and offers little value to the public. Labelling should make clear appropriate information on how to dispose of products alongside whether they are bio-based and/or biodegradable.

Chapter 6 – Impacts on the waste industry

Impacts on the current waste management systems

Q26. What, if any, evidence is available to demonstrate the impact that biodegradable (including compostable) plastics have in the current waste management system, including on the quality and safety of composts and digestates? Does the existing evidence allow to estimate the monetary value of this impact?

Q27. What, if any, evidence is available on the behaviour of bio-based plastics compared to conventional fossil-based plastics in the current waste management system?

Q30. How do anaerobic digestion, composting, and energy-from-waste operators currently manage compostable plastics in areas where food waste is collected in bags/liners?

Summary of responses

6.1 Many respondents were concerned about the potential adverse impacts of biodegradable plastics on the current waste management system. The responses provided, however, were largely based on anecdotal evidence with few robust studies supplied.

6.2 The majority of responses from industrial composters indicate that most do not welcome any form of plastic in their inputs, seeing it as a contaminant, and act to remove this before composting.

6.3 There was some discussion that the levels of plastic permitted in PAS compliant composts are too high. This is a source of many complaints on the quality of composts. As a result, there was concern that wider use of compostable plastics in the future could increase contamination and therefore lead to poorer compost quality.

6.4 A similar picture was described for anaerobic digestion (AD) plants, for which it was claimed that all plastic material causes issues. Responses indicated that in most current wet AD plants, plastic materials are removed before digestion as part of the feedstock preparation process. Reject material is then disposed of to landfill or incinerated in energy from waste plants. This is to avoid operational issues such as blockages, wrapping around moving parts, and accumulation in the digester.

6.5 In some areas, more robust non-biodegradable plastic bags are being recommended for food waste collections as they are easier to remove than most biodegradable plastic bags. Additionally, some reported that biodegradable plastics do not biodegrade sufficiently under commercial anaerobic digestion conditions and are still present in digestates.

6.6 The responses indicated a preference that all plastic material should be separated out from biowaste before being sent for treatment in AD plants.

6.7 With regards to the behaviour of bio-based plastics in current waste management systems, the responses were similarly based largely on anecdotal evidence and suggestions on best practice for waste management varied.

6.8 It was suggested that where the bio-based plastic was a “drop-in” substitute (i.e. of the same chemical structure as a conventional plastic such as polyethylene but made from bio-based sources) then they would perform identically in industrial processes and can be recycled alongside their fossil-fuel based counterparts.

6.9 However, concerns, were raised by some responders that bio-based plastics, irrespective of whether they are biodegradable or not, can still be a source of contamination in the current waste management system. They suggested that some types of bio-based plastic, for example, may be mistakenly identified by recycling machinery as conventional, fossil-fuel derived plastic, and so contaminate recycling streams.

6.10 Other responders considered that mechanical separation of plastics would be feasible. They suggested that specific chemical markers could be added to plastic material to assist their identification in mechanical sorting processes. There was some agreement that material recovery facilities (MRFs) would need to be enhanced where there is co-mingled plastic collection to ensure there is adequate separation to maintain quality of recovered plastics.

6.11 There were no specific responses in regard to quantification of financial issues. One respondent stated that they had experience of negative finances resulting from cross-contamination of recyclable plastic and another indicated half the pre-processing cost of biowaste was associated with contaminating plastics.

6.12 No concerns were raised by respondents of potential adverse impacts of biodegradable plastics being sent for incineration in energy from waste plants.

Potential adaptation of current systems

Q28. How, if at all, would waste collection systems need to be adapted to accommodate the niche introduction of biodegradable plastics?

Q29. How, if at all, would waste collection systems need to be adapted to accommodate the mass introduction of biodegradable plastics?

Summary of responses

6.13 Many of the responses indicated that there is a need for more source separation to accommodate the introduction of biodegradable plastics in the current waste system, to avoid contamination issues with plastics going for mechanical recycling.

6.14 While there are currently comparatively small volumes of biodegradable plastics entering the system, some respondents suggested it would be best for such material to be collected in residual waste to avoid contamination of recyclable plastics.

6.15 Others promoted the introduction of separate collections for biodegradable plastic or, incorporating biodegradable/compostable plastics into biowaste collections. It is important to note that separate biodegradable plastic collections were indicated as requiring additional infrastructure and investment for the collections. Opponents to this idea questioned the cost-effectiveness of these changes given that there are limited quantities of such material and investment could go to more effective solutions, such as increasing domestic recycling capacity.

6.16 Several respondents raised concerns that there is the potential for changes to the waste system to create confusion for the public. There was trepidation that if it were mandated

that biodegradable plastics should be put in biowaste collections, for example, it could result in more non-biodegradable plastics being mistakenly put in to biowaste streams.

6.17 Some respondents felt that disposing of compostable plastics in biowaste collections would be optimal. However, there was widespread recognition that the current composting infrastructure would need significant changes to ensure the material could be effectively treated.

Government response

6.18 Several areas of the waste industry may require additional investment to support the widespread introduction of biodegradable and compostable plastics. To avoid issues of cross-contamination and machine damage, appropriate collection and treatment infrastructure would be required to ensure that such plastic ended up in the appropriate waste stream. Furthermore, AD facilities would need to be upgraded to ensure that they were equipped to manage these materials and ensure a consistent service and method of treatment. Some composting facilities may also require upgrades depending on their current capacity and processes. From the responses, it is clear that there may be significant costs associated with introducing separate collection for such materials and that further consideration is needed in this area before any changes are made.

6.19 This issue is explored further in our consultation on an extended producer responsibility scheme for packaging and will also be discussed in our second consultation on introducing greater consistency in household and business collections.

6.20 We are interested in the role compostable caddy liners may have to play in food waste collection as part of our reforms to household waste collection in England. Evidence suggests that the provision of caddy liners can increase uptake in food waste collection services and, where compatible with local waste management systems, compostable caddy liners may help achieve greater environmental outcomes. More detail on our proposals will be provided in our consultation on consistency in household and business recycling in England and we welcome further feedback on these.

6.21 In accordance with the waste hierarchy and our ambitions in the *Resources and Waste Strategy*, in most circumstances our current preference is for plastics to be reused or recycled. Current systems and processes should not, however, be a barrier to innovation, particularly if such innovation could have environmental benefits. In the case of biodegradable plastics, our view is that they may have a limited but nonetheless valid role to play in a more circular economy, primarily in applications where plastic would otherwise be unlikely to be reused or recycled. Potential negative impacts on the waste industry should be mitigated by clear, consumer-friendly labelling on appropriate disposal.

Chapter 7 – Market factors

Q4. Bio-based plastics currently make up a relatively small proportion of the market, representing around £50m GVA. What, if any, are the barriers preventing innovative bio-based products from succeeding in the marketplace?

Q 21. To what extent, if at all, could biodegradability standards be beneficial for specific products (such as carrier bags) or product forms (for example those that with current technology are typically too contaminated to be mechanically recycled once disposed of)?

Summary of responses

7.1 Evidence in support of perceived barriers to bio-based plastics in the marketplace was limited. There were, however, three reoccurring themes throughout:

- **Scale and sustainability** – there were concerns that the widespread use of land to produce these products would be unsustainable and not desirable in competition with other land use, particularly food production. However, others cited studies suggested that substantial feedstocks for bio-based plastics were now available from existing organic wastes associated with crops such as straw, and that bio-based plastic feedstocks could increasingly be derived from municipal waste.
- **Cost** – production cost of bio-based plastics was cited as a major barrier by many respondents, especially in the context of comparison with current low-cost fossil-fuel based plastics.
- **Waste management** – there were multiple issues relating to the waste management of novel bio-based plastics. These include the current reluctance of composting and anaerobic digestion facilities to accept any plastics in the first place; lack of clarity for citizens on how to dispose of the material; and the potential need for separate collection and treatment from other plastic types.

7.2 On the issue of whether specific products or product forms could benefit from the introduction of standards for biodegradable plastic, many respondents re-iterated the view that single-use items, for example plastic bags, should not be encouraged irrespective of the material they are made from.

7.3 There was some suggestion that biodegradability standards could be most suitable for applications where single-use items are the best, or only option. Clear guidance, and where necessary regulation, on the final end-of-life waste management disposal route is needed. For instance, items such as tea bags, which cannot be mechanically recycled due to the size and soiling of the material, could be sent for composting. The potential use of biodegradable plastic carrier bags to be used in caddies (as a second use) for collecting food waste was questioned due to implications for recycling systems, as explored in chapter 6.

7.4 Concerns were expressed regarding how well biodegradable plastics would decompose in industrial and home composting processes, what residues might remain and the

impact on the quality and marketability of commercial composts, and the impact on the environment from the use of composts. It was suggested that the presence of plastic residues in industrial and home composts would not be acceptable to end users. Development of appropriate standards would be required to help ensure compost and digestate quality is not compromised.

Government response

7.5 The government is committed to ensuring that new innovative technologies can succeed in the marketplace. We want to ensure that innovation in this industry continues, however it is vital that new materials really are more sustainable than conventional plastics and other alternatives.

7.6 Greater use of bio-based materials could provide significant economic benefit whilst reducing our reliance on finite fossil-based resources.

7.7 To date government have pledged £100 million in research and innovation to tackle the issues that arise from plastic waste, including exploring alternative materials. We invested £20 million to set up a Plastics Research and Innovation Fund (PRIF) in 2018. The aim of the PRIF was to explore novel ideas and innovations with the potential to make the plastics sector more circular and address the challenge of persistent plastic pollution. The government has also committed £60 million of funding through the Industrial Strategy Challenge Fund, alongside a £150 million investment from industry, towards the development of smart, sustainable plastic packaging, which will aim to make the UK a world-leader in sustainable packaging for consumer products.

7.8 This investment will help to provide research for enterprising businesses to be able to use this information to develop innovative plastic materials and ensure that existing materials do not cause environmental harm. Under the Plastics Research and Innovation Fund, we supported the development of Skipping Rocks Labs ‘Ooho sachet’, a biodegradable plastic-alternative membrane for packaging fluids, ‘Oceanium’ a seaweed-based compostable, marine safe bio-packaging and inorganic sustainable alternatives to plastic microbeads from Lucideon Ltd. We have also awarded scientists from the University of Bath £2.6 million to examine the environmental impacts of biodegradable plastics.

7.9 The UK Circular Plastics Network provides information on initiatives to reduce plastic waste in the UK. It includes a collaboration platform; a UK plastics roadmap on future opportunities; needs in the supply chain. Information on the PRIF, SSPP, and more funding opportunities can be found on their website.

Chapter 8 – Other issues raised

Q5. Bio-based plastics - What other potential unintended consequences could arise as a result of a growth in use of bio-based plastics?

Q13. Biodegradable plastics - What other potential unintended consequences could arise as a result of a growth in use of biodegradable plastics?

Q31. Is there any other information or evidence related to this topic that the government should be aware of?

Summary of responses

8.1 Many responses described multiple knock-on effects that growth in use of bio-based and biodegradable products may cause. Issues not already summarised in responses to other questions included:

- Whether any general increase in biodegradable waste might lead to more methane emissions.
- Concerns regarding food-based packaging and food safety issues.
- The potential for blockage of sewage systems if unsuitable products are flushed-away.
- Many products which use bio-based plastic are often blended with a significant proportion of fossil-fuel based sources which may reduce the benefits afforded from using bio-based sources.

8.2 Additional observations raised which have not already been covered in this summary were as follows:

- The issue should not be seen in isolation but put holistically in context of all other plastic and plastic waste issues.
- Concern was raised regarding biodegradable plastics that end up in the sewer may not be addressed in current standards.
- Concern that the costs of additional testing associated with bio-based and biodegradable/compostable plastics is a burden not shared by conventional plastics.

Government response

8.3 The government recognises the concerns raised, particularly around the potential negative environmental impacts associated with the use of such new materials and will consider these in future policymaking.

Chapter 9 – Next steps

9.1 The issues associated with the use of bio-based, biodegradable and compostable plastics are complex. We note that there currently appears to be widespread confusion among the general public and industry regarding these innovative materials and the impacts their development and use have on the natural environment.

9.2 This call for evidence has provided us with a valuable evidence base to inform policy decisions as we take forward the *Bioeconomy Strategy* and *Resources and Waste Strategy*. The government has received a wide range of ideas and recommendations in response to the call for evidence. Over the coming months, we intend to explore the following proposals in more depth:

- Commissioning a research project to further consider the evidence that has been supplied to this call for evidence, within the context of wider literature and new research.
- Where this topic cuts across our current policy agenda the government will, as necessary, continue to explore further issues in our consultations such as on an extended producer responsibility scheme for packaging and introducing greater consistency in household and business recycling collections in England.
- BEIS will be able to make use of the evidence provided to this call for evidence through its delivery of *Growing the Bioeconomy: A National Bioeconomy Strategy to 2030* where it was included as an action in the Business Environment chapter.

9.3 As we further consider these issues our drivers will continue to be the ambitions of the *Resources and Waste Strategy* and *Bioeconomy Strategy*, to move towards a more circular economy and develop a world-class UK bioeconomy. Appraisal of new materials against robust standards and credible evidence will be vital to doing so. We will therefore be further considering the evidence received to this call as we move forward with our policy ambitions, including through our work with UKRI.

Annex A – Table of standards

Question 17 asked if there were any other standards for biodegradation which were not covered by the IBioIC review that was published on the gov.uk page with the call for evidence. This table details the information which we received under the question, the descriptions given are taken from responses.

Standard Number	Description
BS 8472:2011	Methods for the assessment of the oxo-biodegradation of plastics and of the phyto-toxicity of the residues in controlled laboratory conditions
DIN EN ISO 10210:2012	Plastics - Methods for the preparation of samples for biodegradation testing of plastic materials (ISO 10210:2012)
EN 13432:2000	Packaging. Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging
EN 14045:2003	Packaging. Evaluation of the ultimate aerobic biodegradability and disintegration of packaging materials under controlled composting conditions. Method by analysis of released carbon dioxide
DIN EN 14987:2007	Plastics - Evaluation of disposability in waste water treatment plants - Test scheme for final acceptance and specifications
EN 14995:2006	Plastics - Evaluation of compostability - Test scheme and specifications

Standards for bio-based, biodegradable, and compostable plastics: Government response

Standard Number	Description
EN 17033:2018	Plastics - Biodegradable mulch films for use in agriculture and horticulture - Requirements and test methods
EN 17417:2019	Determination of the ultimate biodegradation of plastics materials in an aqueous system under anoxic (denitrifying) conditions - Method by measurement of pressure increase
EN 17427:2021	Packaging - Requirements and test scheme for carrier bags suitable for treatment in well-managed home composting installations (publication due)
EN 17428:2021	Packaging - Determination of the degree of disintegration under simulated home composting conditions (publication due)
ISO 846:1997	Plastics — Evaluation of the action of microorganisms
ISO 11266:1996	Soil quality — Guidance on laboratory testing for biodegradation of organic chemicals in soil under aerobic conditions
ISO 10210:2012	Plastics — Methods for the preparation of samples for biodegradation testing of plastic materials
ISO 14855	Determination of the ultimate aerobic biodegradability of plastic materials under controlled composting conditions — Method by analysis of evolved carbon dioxide — Part 1: General method
ISO 15985:2014	Plastics — Determination of the ultimate anaerobic biodegradation under high-solids anaerobic-digestion conditions — Method by analysis of released biogas

Standards for bio-based, biodegradable, and compostable plastics: Government response

Standard Number	Description
ISO 16929:2013	Plastics — Determination of the degree of disintegration of plastic materials under defined composting conditions in a pilot-scale test
ISO 17088:2012	Specifications for compostable plastics
ISO 19679:2016	Plastics - Determination of aerobic biodegradation of non-floating plastic materials in a seawater/sediment interface - Method by analysis of evolved carbon dioxide
ISO 18606:2013	Packaging and the environment - Organics Recycling
ISO 20200:2015	Plastics — Determination of the degree of disintegration of plastic materials under simulated composting conditions in a laboratory scale test
ISO 22404:2019	Plastics — Determination of the aerobic biodegradation of non-floating materials exposed to marine sediment — Method by analysis of evolved carbon dioxide
ISO/DIS 22403:2020	Plastics -- Assessment of the inherent aerobic biodegradability and environmental safety of nonfloating materials exposed to marine inocula under laboratory and mesophilic conditions
ISO/DIS 22526-1:2020	Plastics — Carbon and environmental footprint of biobased plastics — Part 1: General principles
ISO/DIS 22526-2:2020	Plastics — Carbon and environmental footprint of biobased plastics — Part 2: Material carbon footprint, amount (mass) of CO2 removed from the air and incorporated into polymer molecule

Standards for bio-based, biodegradable, and compostable plastics: Government response

Standard Number	Description
ISO/DIS 22526-3	Plastics — Carbon and environmental footprint of biobased plastics — Part 3: Process carbon footprint, requirements and guidelines for quantification (under development)
ISO/CD 23977-1	Plastics -- Determination of the aerobic biodegradation of plastic materials exposed to seawater -- Part 1: Method by analysis of evolved carbon dioxide (under development)
ISO/CD 23977-2	Plastics -- Determination of the aerobic biodegradation of plastic materials exposed to seawater -- Part 2: Method by measuring the oxygen demand in closed respirometer (under development)
ASTM D5338-15	Standard Test Method for Determining Aerobic Biodegradation of Plastic Materials Under Controlled Composting Conditions, Incorporating Thermophilic Temperatures
ASTM D5511-18	Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under High-Solids Anaerobic-Digestion Conditions
ASTM D5526-18	Standard Test Method for Determining Anaerobic Biodegradation of Plastic Materials Under Accelerated Landfill Conditions
ASTM D5929-18	Standard Test Method for Determining Biodegradability of Materials Exposed to Source-Separated Organic Municipal Solid Waste Mesophilic Composting Conditions by Respirometry
ASTM D6400-19	Standard Specification for Compostable Plastics/Standard Specification for Labelling of Plastics Designed to be Aerobically Composted in Municipal or Industrial Facilities

Standard Number	Description
ASTM D6868-19	Standard Specification for Labelling of End Items that Incorporate Plastics and Polymers as Coatings or Additives with Paper and Other Substrates Designed to be Aerobically Composted in Municipal or Industrial Facilities
ASTM D6932-13	Standard Guide for Materials and Construction of Open-Graded Friction Course Plant Mixtures
ASTM D6954-19	Standard Guide for Exposing and Testing Plastics that Degrade in the Environment by a Combination of Oxidation and Biodegradation
ASTM D7475-20	Standard Test Method for Determining the Aerobic Degradation and Anaerobic Biodegradation of Plastic Materials under Accelerated Bioreactor Landfill Conditions
OECD 301C (1992)	MITI Biodegradation Test
OECD 301F (1992)	Biodegradation Test – O2 Consumption
OECD 302C	Inherent Biodegradability: Modified MITI Test (II)
OECD 302F	Not provided
UAE/S 5009	Not provided
SASO 2879	See BS 8472

Annex B – References and data sources cited by respondents

As well as the frequently cited study indicated in the call for evidence (IBioIC, "A Review of Standards for Biodegradable Plastics") there were a number of sources of data and published works cited in the responses.

This section lists most of the cited references and data sources. The government has not validated their content and does not endorse them or suggest that they are reflective of HMG views or policy. There may be some duplication of data sources in different themes due to their relevance for multiple chapters.

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Annex C – List of respondents

Anglia Ruskin University

ASDA

Biffa

Bio-based and Biodegradable Industries Association (BBIA)

BioLogiQ Inc LLC

Biome Technologies

BioPak

BNT. Force Biodegradable Polymers

Braskem

British Plastics Federation (BPF)

British Standards Institute (BSI)

Brown Bag Crisps

Bunzl Catering Supplies

Cedo

Centre for Ecology & Hydrology

Co-op

Comply Direct

Dow Packaging

East Dorset Environment Partnership

Ecosustainable Polymeric Materials Laboratory (LMPE srl)

Energy-W

Energy Services Association (ESA)

Fidra

Food and Drink Federation (FDF)

Food Service Packaging Association

Frugalpac Ltd

Futamura UK Ltd

Grantham Centre for Sustainable Futures

Green Alliance

GS Polymer Consultants

Hants County Council

Hi Cone World Wide

Higginson Strategy

Huhtamaki

IChemE

INCpen

J & F Powner Ltd

Johnson Matthey

Leeds City Council

Leicestershire County Council

Loowatt Ltd

Lucozade Ribena Suntory

Nafigate Corporation

National Association of Waste Disposal Officers (NAWDO)

Natural England

NatureWorks LLC

Nestle

News Media Association

Omnexus

PacTec Limited

Polymateria

Professional Publishers Association

Regalzone

Renewable Energy Association (REA)

Renewable Energy Assurance Ltd (REAL)

RSK ADAS Ltd

Rosti

Roundtable on Sustainable Biomaterials

Suez Recycling

Sulapak Ltd

Sku-Driver

The Law Society of Scotland

The Oxo-biodegradable Plastic Association

Unilever

University College London (UCL)

University of Cambridge

University of Hull

University of Manchester

University of Nottingham

University of Plymouth

University of Queensland

University of Reading

University of Warwick

Vegware

Veolia

Waste and Resources Action Programme (WRAP)

Wells Plastic

West London Waste Authority

Wildlife and Countryside Link

The government also received a small number of responses from individuals who responded in a private capacity.

This publication is available from: www.gov.uk/government/consultations/standards-for-biodegradable-compostable-and-bio-based-plastics-call-for-evidence

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