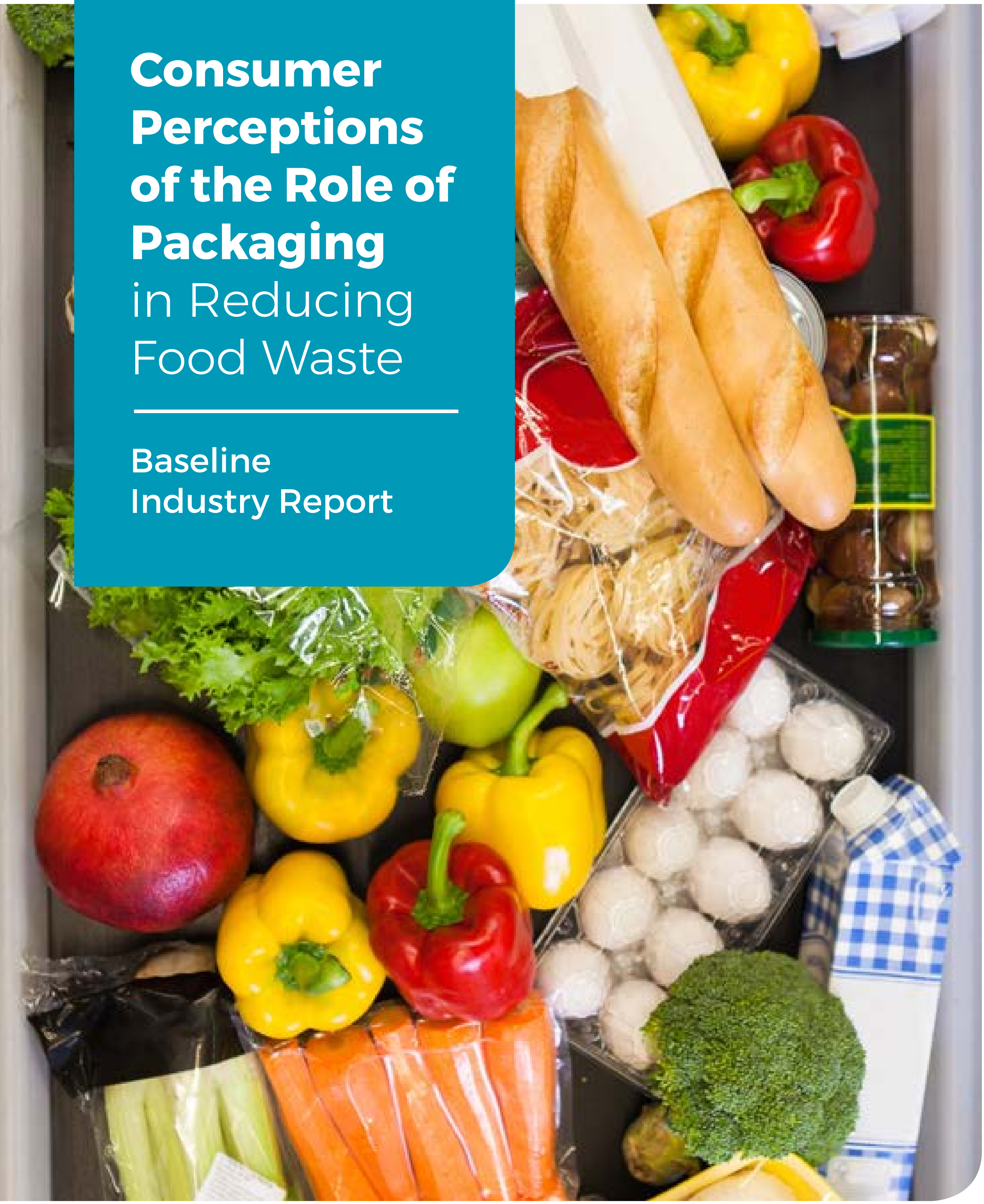
Consumer Perceptions of the Role of Packaging in Reducing Food Waste

Baseline Industry Report



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Australian Government
Department of Industry, Science, Energy and Resources

Business Cooperative Research Centres Program

Consumer Perceptions of the Role of Packaging in Reducing Food Waste

Baseline Industry Report

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The CRC Program supports industry-led collaborations between industry, researchers and the community.

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DISCLAIMER
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Executive summary

Reducing food waste is widely seen as a significant way to lower production costs, increase the efficiency of the food system, improve food security and nutrition, and contribute towards a more environmentally sustainable food system. Food waste at the consumer level is often caused by poor purchasing habits, confusion over labels, excess buying, and poor storage. Packaging is often viewed as having a negative impact on the environment. However, in many cases packaging protects food and prolongs shelf life, reducing a product's overall environmental impact by reducing food waste. Food packaging can reduce household food waste when it is designed to extend the shelf life of food products, available in various sizes for different sized households, communicates the best way to use and store food items, uses date labels to assist households to better manage their food, and to slow the degradation of minimally processed fruits and vegetables.

Understanding, perception, and use of packaging by consumers also play a role in household food waste generation but is not clearly understood. **This industry report reviews the existing literature to scope the recognised knowledge in the fields of food packaging and food waste relating to consumers' expectations, to inform food producers, packaging designers, and retailers in their strategies and educational campaigns.** It is envisaged that this baseline literature review will be later developed through Fight Food Waste CRC into research papers that identify and develop save food packaging solutions in collaboration with food retail industry and government partners.

The five main food categories defined for this project are meat and seafood, bakery, packaged and processed foods, dairy and eggs; and fresh fruit and vegetables. Although leftovers have been identified in various studies as a major contributor to household food waste, this category is beyond the scope of this project as cooked meals no longer involve the packaging in which the food was sold.

The review adopted a systematised review method with both academic literature and grey literature included.

34%
of all food waste in Australia is consumer food waste

92%
of this waste ends up in landfill

This industry report reviews the existing literature to scope the recognised knowledge in the fields of food packaging and food waste relating to consumers' expectations, to inform food producers, packaging designers, and retailers in their strategies and educational campaigns.

In Australia and New Zealand, it is estimated that about 5-6% of all food produced in 2016 was lost in the retail and consumer stages of the food system, while 13.8% was lost at these stages globally. It has been calculated that consumer food waste in Australia accounts for 34% of all food wasted across the food supply chain, with 92% of this waste ending up in landfill. The existing literature shows that there are a wide variety of factors that influence consumer behaviour with food that is wasted.

This report finds that the literature around this issue identifies four broad categories of factors that drive food waste in households: values, the challenges of everyday life, managing stock in households, and material factors of food and packaging. The existing literature also quantifies sales volumes in Australia of the five different food categories, and this report collates this data with estimates of food waste in each of the categories, and with findings that show the global warming potential of these foods based on Life Cycle Assessments.

This report also details the existing functional packaging features that save food waste, and the reasons for food waste that could be overcome by packaging design. In particular, there are emerging packaging technologies that are known as smart, active or intelligent packaging. Active packaging relates to packages that have a more active role than simply containing and protecting foods, while smart or intelligent packaging senses information about the food it contains and communicates that information to suppliers, retailers, or consumers. This report finds that while there is some existing research about consumer attitudes towards these technologies, it is sparse. We therefore make several recommendations:

Understanding consumer households and their practices

More research is needed to understand household practices with food packaging and food waste and how these insights can be used to inform product-packaging design.

PACKAGING TARGETS TO BE ACHIEVED BY 2025

100%
reusable, recyclable, or compostable packaging

70%
of plastic packaging being recycled or composted

30%
average recycled content included in packaging

phasing out of single-use plastics packaging

Australian Packaging Covenant Organisation, 2019

This research will need to understand the ways issues related to packaging and food waste might vary across different kinds of households. This research would aim to understand broad consumer perceptions of food packaging and its potential to reduce food waste, and whether and how different households engage with different pack sizes for foods in the five food categories.

Consumer education

Much of the existing literature recommends consumer education about the role of packaging in reducing food waste. We further recommend that testing be undertaken with consumers to understand how they interact with and understand on-pack information and date labels; that an investigation be undertaken to understand what delivery method/s would be appropriate for consumer education campaigns about packaging features (e.g. social media, websites, short videos, infographics) and the level of detail required; and that the findings from these investigations need to integrate into existing government education campaigns such as the Love Food Hate Waste program.

Using consumer insights to inform industry and develop packaging design

The report finds that there is currently a gap between the development of packaging technologies that reduce food waste and insights about how consumers engage with food packaging. Consumer insights should be used to both inform industry and develop packaging design. It is also necessary to consider how industry would integrate these consumer insights, who in the supply chain (consumers or otherwise) benefits from extended shelf life, and how date labelling could be standardised so that communication about shelf life is clear across the supply chain and to consumers.

Requirements for end-of-life options

In both the Australian and the UK context, the recyclability of food packaging has been an increasing focus. Existing literature has recommended that food waste be highlighted as an issue that should be considered in that plan. We further recommend that consumer perceptions of packaging reuse, recyclability, and/or compostability, and the likelihood of acceptability of these packaging options should be further investigated. In addition, it will also be important to understand potential trade-offs and negative environmental impacts (e.g. more food waste) of packaging material design decisions that compromise product shelf life, for instance in order to achieve the national packaging targets.

Contents

01

Introduction

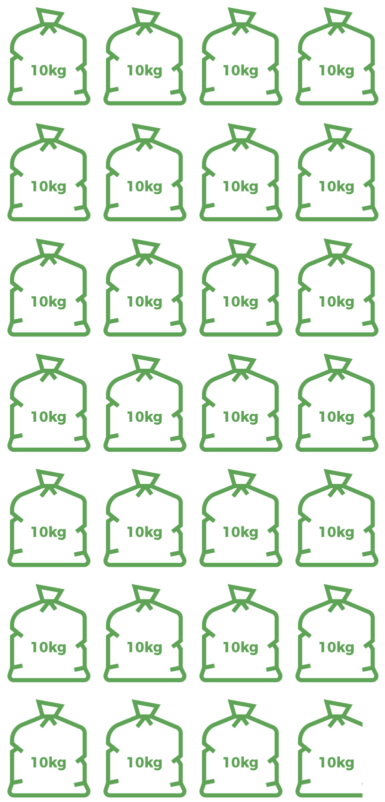
Food waste is a significant environmental, economic, and social issue [1], and reducing food waste is widely seen as a significant way to lower production costs, increase the efficiency of the food system, improve food security and nutrition, and contribute towards a more environmentally sustainable food system [2]. Reducing food waste is a way of managing demand for food, which is a key part of creating sustainable food systems to meet the world's growing population [3].

Food waste at the consumer level is often caused by poor purchasing habits, confusion over labels, excess buying, and poor storage [2]. Packaging is often viewed as having a negative impact on the environment. It is leftover once products are consumed and the customer disposes of it either in the bin or through recycling. However, in many cases packaging protects food and prolongs shelf life, reducing a product's overall environmental impact by reducing food waste [4]. Food packaging can reduce household food waste by being designed to extend the shelf life of food products, being available in numerous sizes for different sized households, communicating the best way to use and store food items, assisting households to use date labels to better manage their food, and slowing the degradation of minimally processed fruits and vegetables. Understanding the perception and use of packaging by consumers also plays a role in household food waste generation. The negative perception of food packaging and the lack of understanding of its functional role in reducing food waste within households requires more discussion and consumer research. **This industry report – a review of the existing literature – aims to scope the recognised knowledge in the fields of food packaging and food waste relating to consumers expectations, to inform food producers, packaging designers, and retailers in their strategies and educational campaigns.**

The five main food categories defined for this project are meat and seafood, bakery, packaged and processed foods dairy & eggs; and fresh fruit & vegetables*.

*This list has been adapted from Sustainability Victoria's 2018 report and is based on the products consumers identified as being the most wasted in their households.

$20 Billion
is the estimated value of food waste in Australia



298 kg per capita
of food waste was generated in 2016/17

Although leftovers have been identified in various studies as a major contributor to household food waste, this category is beyond the scope of this project as cooked meals no longer involve the packaging in which the food was sold.

Nearly two thirds (57.9 %) of fresh food (including foods in the meat and seafood, dairy and eggs, and fresh fruit and vegetables categories) sold in Australia in 2018 was sold in supermarkets, and just under half (49.8%) of that was packaged [5]. In 2018, 6 270 000 tonnes of fresh food were sold in Australia. This is expected to grow by 15.7% by 2023 [5]. Similarly, nearly two thirds (59%) of baked goods in Australia sold in 2018 were sold through supermarkets. In 2018, 878 300 tonnes of baked goods were sold in Australia. This is expected to grow to 938 400 tonnes by 2023 [6]. In 2018, 71.5% of packaged and processed foods (including dairy) sold in Australia were sold in supermarkets. This amounted to 6 129 000 tonnes of food and is projected to grow to 7 007 400 tonnes by 2023 [7].

Further detail about the sales of food in the five categories is provided in **Figures 2-6** in **Section 3.2**

It has been estimated that the value of food waste in Australia is $AUD20 billion [8]. According to the National Food Waste Baseline, Australia generated 11.8 million tonnes of food waste in 2016/17, of which four million was diverted to food rescue and animal feed [8]. The most significant stages of the supply chain at which the remaining 7.3 million was generated include primary production (34%), households (34%), and manufacturing (24%). This equates to 298 kilograms per capita, which constitutes the National Food Waste Baseline [8].

Given that food packaging can contribute to reducing food waste, understanding consumer perceptions and use of packaging plays an important role in household food waste reduction. In an Australian context, future developments in food packaging will also need to consider the 2025 National Packaging Targets currently being developed by the Australian Packaging Covenant Organisation [9].

This review has been organised into three sections. The first addresses consumer behaviour and food waste to highlight issues that could be addressed by food packaging. The second section addresses literature regarding 'save food packaging' and its functional features that aim reduce consumer-generated wastage. The third looks at emerging packaging technologies.

This baseline literature review aims to understand what is already established about consumer perceptions of the role of food packaging in reducing food waste. The articles reviewed in the proceeding sections provide background research on food packaging and its impact on consumer-generated food waste in households. This review has been organised into three sections. **Section 3** addresses consumer behaviour and food waste to highlight issues that could be addressed by food packaging. **Section 4** addresses literature regarding 'save food packaging' and its functional features that aim reduce consumer-generated wastage. Save food packaging is defined by the Australian Institute of Packaging [10] as packaging "designed to minimise or prevent food waste from paddock to plate using innovative and intuitive design features that can contain and protect, preserve, extend shelf life, easily open and reseal, provide consumer convenience and portion control; all the while meeting global sustainable packaging targets and with the lowest environmental impacts". **Section 5** looks at emerging packaging technologies. Very little research currently exists that aims to understand the ways consumers perceive and make use of existing packaging solutions to reduce food waste, and the ways they might perceive the kinds of technologies being developed.

The methodology for this baseline literature review is explained in the next section. This is followed by the literature review itself. The paper concludes with insights and recommendations for future research, including activities within this Fight Food Waste CRC Project. It is envisaged that this baseline literature review will be later developed into research papers that identify and develop save food packaging solutions in collaboration with food retail industry and government partners.

02

Methodology

A five-step selection process was developed:

- search strategy executed with results exported and stored;
- article abstracts appraised on relevance;
- duplicates omitted;
- full-text reviewed and ranked;
- studies categorised and documented.

The purpose of this baseline literature review is to scope the research landscape relating to the key topics of interest for the wider Fight Food Waste CRC Project. It will guide future literature reviews and research in for consumer studies. From the numerous literature review methods acknowledged by Grant and Booth [11], this research closely adopts a systematised review method. This method is founded on the following elements, adapted from Grant and Booth:

- a comprehensive literature search of topic-specific keywords,
- a systematic and clearly designed search strategy,
- a quality audit, in line with identifiable hierarchies of evidence,
- analysis and synthesises of search results.

RMIT University Library databases and food packaging platforms were accessed for both academic and grey literature. Search parameters were established as relevance, dates of publication (between 2014 and 2019 inclusive), English language, and peer-reviewed articles or 'landmark' publications from grey literature. Additional publications outside of the date parameters were also included in the review if they were often cited by authors whose work was published within this date range, and/or if they were otherwise considered to be substantial or needed to understand factors related to this project that were not covered in literature from within the date parameters. Additional subject categories that limited the searches further were selected on the topics of 'food packaging' AND/OR 'food waste'. Boolean search terms were used to combine the primary search terms – 'food packaging' and 'food waste' with the third tiered search terms: 'design', 'reducing', 'efficient', 'life cycle assessment' (LCA), 'circular economy', 'consumer perceptions', 'consumer behaviour', food category-specific fields ('baked goods', 'vegetables', 'fresh fruit', 'cooked food', 'seafood', 'meat', and 'dairy'), best before information, and 'portion control'.

A five-step selection process was developed:

- search strategy executed with results exported and stored;
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03

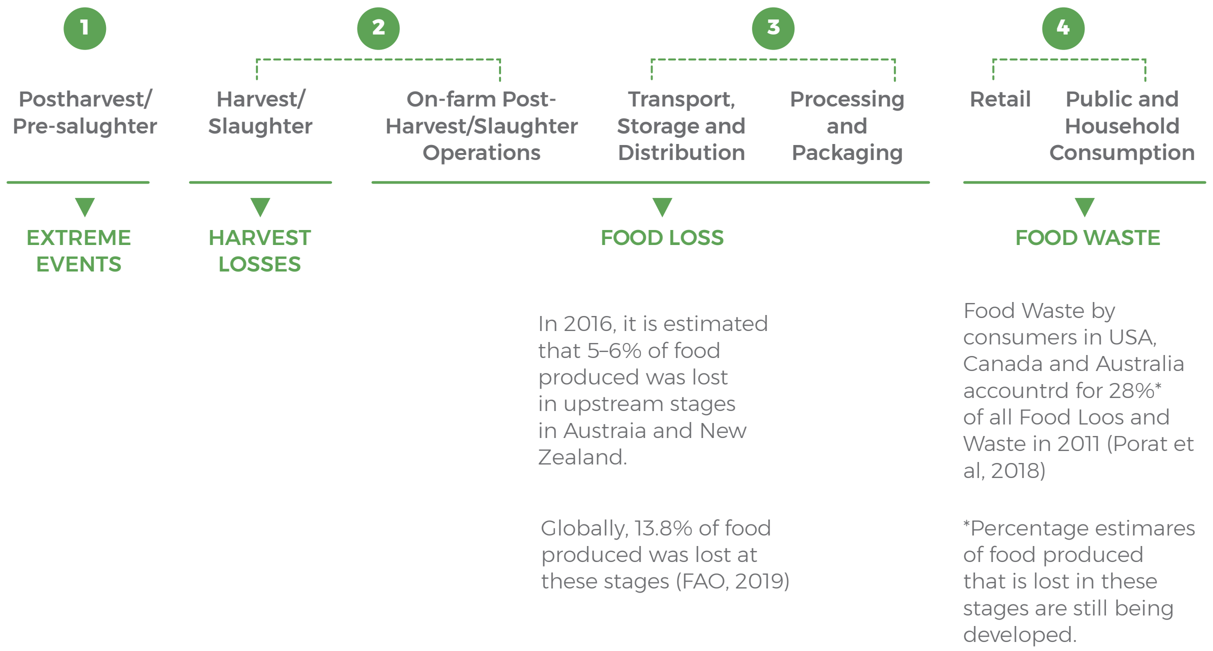
Consumer behaviour and **food waste**

Most definitions consider 'food' to mean foodstuffs intended for human consumption – a definition this project will also use. Food loss and waste (FLW) occurs along the food supply chain (FSC). Definitions for FLW across the literature are multiple, varying as to which stages of the FSC are included (and whether a distinction is made between food loss and food waste), which end-of-life options are considered FLW, and the inclusion or exclusion of inedible parts [12]. Some of the literature also differentiates between loss of quantity and loss of quality [2]. The stages of the FSC are often separated into 'upstream' (production and distribution) and 'downstream' (retail and consumer) [12]. As shown in **Figure 1**, food loss is commonly understood to occur in the upstream stages of the FSC, as a result of decisions and actions by suppliers. Food waste is understood to occur at the downstream stages as a result of decisions and actions taken by retailers and consumers [2].

The Fight Food Waste CRC project is concerned with investigating food waste by consumers in their household (food waste that occurs during the 'downstream' stages of the FSC), where food waste is defined as the preventable disposal of food.

FIGURE 1

Stages of the food system and estimated food loss and waste



Adapted from Spang et al 2019; FAO 2019; Porat et al 2018

In Australia and New Zealand, it is estimated that about 5-6% of all food produced in 2016 was lost in the upstream stages [2]. Globally, 13.8% of food produced was lost at these stages [2]). The UN Food and Agriculture Organisation (FAO) [2] is currently developing a Food Waste Index that will estimate food waste at the retail and consumer stages. However, Porat, Lichter and colleagues [13] analysed FAO food balance sheets and found that consumer food waste in the United States, Canada, and Australia accounted for 28% of FLW across the FSC. As mentioned above, the Australian Government's National Food Waste Baseline report claims household food waste in 2016/17 accounted for 34% of all food wasted across the FSC, with 92% of this waste ending up in landfill [8].

The following sections draw together existing work and understandings about consumer behaviour and food that is wasted in households. It gives an overview of the ways consumers have been categorised by various literature, the drivers of household food waste that have been identified, and existing interventions in household food waste behaviour.

3.1

Drivers of food waste from a consumer behaviour perspective

There are a wide variety of factors that influence consumer behaviour with food that is wasted. These broadly relate to the relationship between consumers' willingness to consume [14] based on freshness or perceived freshness, and their willingness to waste them [15].

In their review of the existing literature on consumer behaviour and household food waste, Hebrok and Boks [16] identify three broad categories of factors that drive food waste in households: values, the challenges of everyday life, and managing stock in households. They group more specific drivers of household food waste under each of these broad categories. Spang and colleagues [12] identify an additional overarching driver that is significant for this project: material factors, including the material properties of food and its packaging. Combined, these two frameworks are useful for understanding the range of factors that contribute to consumer behaviour with food waste. This review places Spang and colleague's [12] "material factors" under Hebrok and Boks' [16] "managing stock in households" category.

Thus, Hebrok and Bok's three broad categories have been used in this review to summarise the findings of the existing literature.

3.1.1

Values

Values and perceived value of food

Broader consumer values have been found to have an impact on consumer behaviour with food waste, and these values are often linked – though not always neatly – to awareness of food waste as a problem, and attitudes towards this problem. These values could also have an impact on consumers' perceptions of food packaging, although no research currently exists to explore this. For instance, environmental values have been found to be associated with lower self-reported amounts of household food waste, where high materialistic values have been associated with higher self-reported amounts of household food waste [17]. Other research has suggested that religious beliefs might also positively impact consumers' motivation to increase environmental awareness and reduce food waste [18].

Income and the economic value of food has also been found to impact consumer behaviour around food waste – perhaps a stronger predictor of reducing food waste than having strong environmental values [19]. Several studies have found that higher-income households produce more food waste than lower-income households [18, 19, 20]. In Egypt, for instance, high-income consumers produce more food waste than low-income [18]. A European study across 27 countries found that the richest and most developed countries produced the most food waste, and that there is an association between the perception of wasting money and the tendency to waste less food at home [21]. In contrast to this, some research suggests that low-income households might produce more food waste by striving for an appearance of abundance or using purchasing strategies that aim to save money, such as buying in bulk and cooking from scratch [22]. In an Australian context, consumers were found to have low levels of awareness of the dollar value of food waste [23]. Some studies have also found that income does not impact consumers' attitudes towards food waste [24, 25].

Income and the economic value of food has also been found to impact consumer behaviour around food waste — perhaps a stronger predictor of reducing food waste than having strong environmental values.

Other research found that living rurally meant income did not impact food waste levels [20, 24], which may suggest that whether consumers live rurally or in urban or suburban areas has an impact.

Some studies conceptualised 'consumer types' to suggest different value sets. Amato and colleagues [26] identify four emotional types: "opulents", "fighters", "apathetic", and "forgiving". "Opulents" associate feelings of joy and gaiety with food waste, which the authors suggest could be because surplus food is associated with feelings of abundance. "Fighters" have strong negative emotions associated with food waste. "Apathetic" participants in Amato and colleagues' study did not associate any negative feelings with food waste, and "forgiving" participants were more resigned and forgiving towards food waste. Among rural dwellers, Di Talia et al [24] also identify distinct types of consumers: those who are unaware of the problem of food waste and are wasteful, those who are unaware but are not wasteful, and "conscious consumers", who are aware and wasteful. Richter [28] categorises consumers who waste food as "guilty food wasters", "unwitting food wasters", and "careless food wasters". Visschers, Wickli and colleagues [28] also identified a type of consumer who was more likely to generate more food waste: "the good provider identity".

Awareness and attitude

Generally, there is a positive correlation between intention to avoid or reduce food waste and actual or reported levels of food wastage [20, 28]. However, it has also been argued that raising awareness and giving people information about the impact of food waste is not enough to change behaviours [29]. Additionally, Diaz-Ruiz, Costa-Font and colleagues [17] argue that food waste is not simply a matter of the perceived value of food, although it has mostly been approached as a food-related problem. They argue that it is also important to approach this issue as a waste-related problem and examine consumers' waste-avoidance values and behaviours, as high levels of these values and behaviours have been found to decrease food waste [17]. Treating food waste as a waste-related problem might also illuminate attitudes and levels of awareness among consumers about the role of packaging in reducing food waste, since packaging might be perceived by consumers as a waste-related problem rather than a food-related problem.

3.1.2

Challenges of everyday life

Much of the existing literature examines the impact the challenges of everyday life have on creating or avoiding food waste. This literature explores different types of consumers, household makeup, planning, attitudes towards food, attitudes towards food safety, and practices with leftover food. Each of these factors could also impact consumers' perceptions of the role of packaging in reducing food waste.

Households and lifestyle

Households with more than two adults and households with children were found to produce more food waste [19, 28, 30]. The impact of having children in the household could be explained by the higher likelihood of children having changing food preferences and eating patterns [31]. Larger households could be more likely to have a range of different tastes to cater for [32].

Age has also consistently been found to be a factor in determining the likelihood of wasting food. Older consumers are less likely to waste food [19, 20, 23, 29]. Younger consumers are more likely to waste food [28], and food waste has been found to make up the largest component of young consumers' overall waste generation, ahead of paper, plastic, glass, metals and other waste [33].

Households with more than two adults and households with children were found to produce more food waste.

It is unclear from the existing literature whether gender has a consistent impact on the generation of food waste, with some research suggesting female respondents are more likely to report generating food waste [28], and other research suggesting the opposite: that men waste more than women [23, 24]. The discussions about this factor tend to suggest that the role a person plays in the household (i.e. how involved they are in meal preparation etc.) has an impact on their contribution to food waste. Household role may also affect perceptions of the role of packaging in reducing food waste.

Planning

Shopping habits are commonly cited as major predictors of food waste [19, 23, 34, 35]. Shopping frequency and the level of disciplined purchasing behaviour (i.e. shopping with a list or buying only what is needed) are two important factors. Some research suggests that longer intervals between shopping trips increases food waste [24], but other research suggests that shopping frequently increases food waste, especially among male respondents [33]. Disciplined purchasing behaviour decreases food waste [17]. Related to this, despite the best intentions of some consumers who reported checking their existing food stocks before they went shopping for food, many bought too much food, either because they were attracted by supermarket special offers or because they shopped frequently [33]. An additional challenge for planning shopping is that food is often only available in a size that is inappropriate for the size of the household [32]. For instance, the amount of bread per package is often too high to be used in the appropriate time by households [36]. Similarly, yoghurt that comes in a multipack is often discarded still in its packaging, which suggests that the number of pots in these multipacks should be reduced [36]. Meat and seafood are also often wasted because the amount per package is too much [36]. These are all important factors to consider when designing food packaging to help reduce food waste.

Leftovers

Leftovers have been found by some research to be one of the most important contributors to food waste [19, 23], and kitchen and refrigerator tidying the most common point of discard or disposal [37]. The size of packaging may also contribute to the wastage of leftovers [36]. Consumers are sometimes either unwilling to eat leftovers or store the leftovers for so long that they become inedible [22]. Consumers may be unwilling to eat leftovers because of concerns about food safety, and these consumers are less likely to reduce food waste overall [38]. There is an opportunity here for packaging to provide more detailed information about any health risks of consuming leftovers of particular food products [28].

Unwillingness to consume leftovers may also be related to a dislike of eating the same food more than once, or disgust at the thought of storing or eating leftovers [39].

Waste-related behaviours

Diaz-Ruiz and colleagues [17] have suggested there is a gap in food-waste related research around consumers' waste-generation behaviours, and this literature review supports Diaz-Ruiz and colleagues' claim. Evans [31, 32] also highlights the impact of waste-related behaviours, suggesting that waste is primarily about what constitutes the practice of disposal. There is a gap in household waste practices, Evans argues, between surplus food (greater than what is needed) and excess food (food that is no longer edible), where alternatives to binning are available [31, 32]. Packaging could play a role here by delaying the movement of food from surplus to excess, and we have therefore added this sub-section to Hebrok and Boks' [16] umbrella category of "the challenges of everyday life".

3.1.3

Managing stock in households and material factors

Storage

Issues with storage commonly contribute to consumers' food wastage. Improper storage and the need for support for consumers to develop better storage and food preservation methods are highlighted by some studies [33, 40]. Consumers who lacked a structured and organised storage system a more likely to waste food because it was not visible in its storage location and was only remembered after it had expired [40]. Other consumers reported wasting food because it had been stored in inappropriately [33].

Wikström and colleagues [36] have suggested that packaging could include information about how to store a food product in the freezer – for instance, optimal storing temperature or the length of time a product can be stored – which may help to reduce food waste. The Waste and Resources Action Programme (WRAP) also recommended that food labelling include clear information – using effective graphics – to indicate ideal storage conditions for food products [41].

Respondents discarded food because they felt it was unsafe or had deteriorated, and that this was more likely to be the reason for discard as participants' socioeconomic status increased.

Packaging

Packaging has already been highlighted as a contributor to food waste in some studies. The main finding of these studies has been that packaging is not currently adequate to keep food fresh and edible. However, from this literature, it is unclear whether this is only consumers' perception of packaging or the reality of the situation. Aschemann-Witzel and colleagues [37] found that consumers felt they wasted food that had been lower quality when it was bought and suggested that this showed that packaging could be used to help maximise the food quality throughout the supply chain. Di Talia and colleagues [24] similarly found that unsuitable packaging was one of the main reasons for food wastage among rural dwellers because it caused consumers to have issues with storing the food. For example, cheese often comes in packaging that is not resealable, which likely leads to its quality diminishing quickly; consumers have reported that ham similarly diminishes in quality quickly, which could be mitigated by resealable packaging; and consumers often find yoghurt containers difficult to empty [36]. There is a high potential for the functionality of packaging to reduce food waste by considering the needs and practices of consumers. Recommendations gleaned from the literature are discussed in more detail in **Section 6**.

Food risk

Food risk has been shown to be a significant concern for consumers that contributes to food waste. Evans [31, 32] has argued that the material nature of food contributes significantly to its wastage, and that concerns about food safety tend to override those about the impact of food waste. Aschemann-Witzel and colleagues [37] have also found that respondents discarded food because they felt it was unsafe or had deteriorated, and that this was more likely to be the reason for discard as participants' socioeconomic status increased. Perceptions of packaging's contribution to reducing food *risk* may also affect perceptions of food packaging's role in reducing food waste.

Date labels dates and food risk

Date labels have been added to this sub-category of Hebrok and Boks' [16] model as a concern that is relevant to the overall project. Different kinds of date labelling on food indicate different things, though this is not always clear to consumers. 'Best before' dates are an indication of food quality, where 'use by' dates are an indication of food safety.

Food having reached or passed its expiration date was a common reason given for discarding food in many studies [15, 33, 38]. Young consumers discarded expired food regardless of whether it was showing signs of deterioration (especially food in the dairy and eggs, and the meat and seafood categories) [33, 36, 38]. Both Konuk [42] and Hall-Phillips and Shah [43] found that consumer confusion about date labels due to inconsistency in formatting and placement on packaging could lead to food wastage and that consumers misunderstanding date labels as giving information about food safety (rather than freshness) commonly leads to edible food being wasted. Along these lines, Wilson, Rickard, and colleagues [15] also found that date labels most suggestive of a food safety issue lead to more food being wasted, whilst date labels most suggestive of a food quality issue lead to the least amount of food wasted. A possible solution for the issues with date labels could be to use dynamic 'best before' dates [36].

Food risk perception is also an important factor for consumer behaviour around date labels. Consumer response to different kinds of food date labels is also influenced by risk perceptions, so educating consumers about labels' meanings would also need to address risk perception [14]. It has been argued that some of the obvious solutions to food waste actually increase the food safety risk to consumers [44].

> Consumer confusion about date labels due to inconsistency in formatting and placement on packaging could lead to food wastage and that consumers misunderstanding date labels as giving information about food safety (rather than freshness) commonly leads to edible food being wasted.

3.2

Food waste behaviours with five food categories

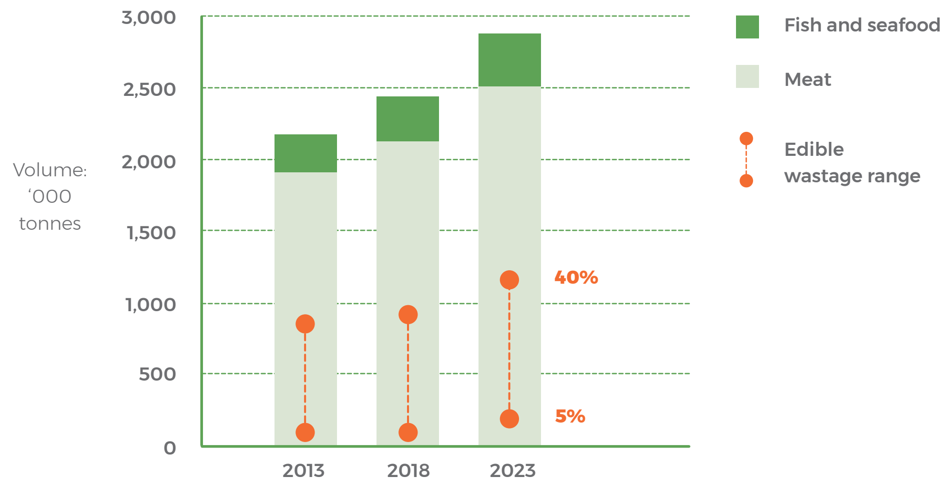
As discussed in **Section 1**, the five food categories defined for this project are meat and seafood, bakery, packaged and processed foods, dairy and eggs, and fresh fruit and vegetables. Although leftovers have been identified in various studies as a major contributor to household food waste, this category is beyond the scope of this project as cooked meals no longer involve the packaging the food was sold in. This section collates existing data from Euromonitor about volumes and sales value of food* in Australia in these categories, the estimated volumes of food wasted in Australia in each of the categories, the global warming potential (GWP) of food in the different categories, and the percentage contribution to food waste in Australia of each of these categories.

Figure 2 to **Figure 6** show the volume of food purchased within the different categories between 2013 and 2018, as well as projections for purchases towards 2023, alongside the calculated ranges of the volume of food wasted in each of these categories. (The data for food purchased in Australia in the five categories can be found in the Appendix.) The percentage range of household purchase wasted calculated by Reutter and colleagues [45] for each food category has been used to project the volume that could be wasted in 2023 if current trends continue.

* Euromonitor collects data from official statistics, trade associations, trade press, company research, store check, trade interview and trade sources.

FIGURE 2

Food purchased and wasted in Australia: meat and seafood

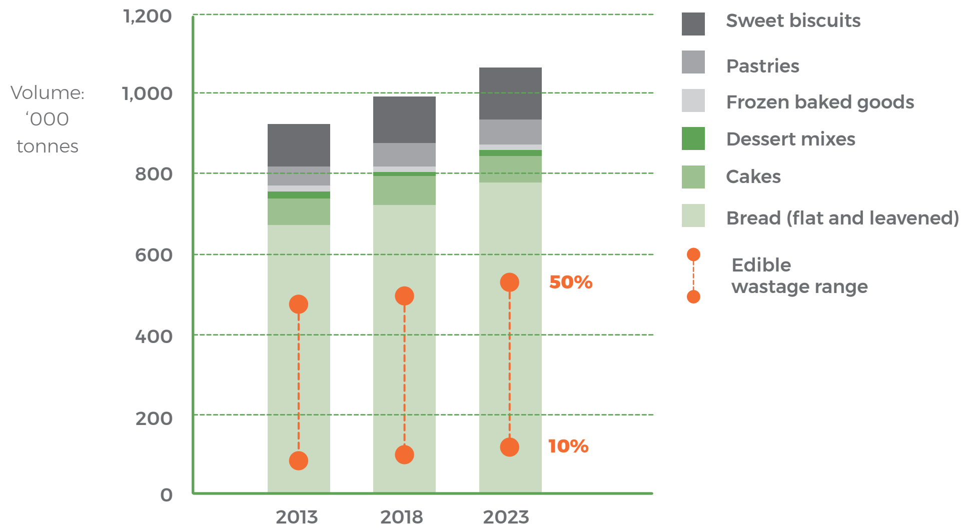


(Data adapted from Euromonitor (2019, 2018a, 2018b); Reutter et al 2017)
Note: values are presented in Table 8 of the Appendix (p 37)

Reutter and colleagues [45], on whose data we have drawn for the volumes of food wasted in Australia, critique the methods used to calculate and characterise food waste, showing that different methods of calculation can give vastly different results [45]. Others have also acknowledged the difficulty in characterising household food waste [2]. Reutter and colleagues [45] found that one calculation method suggested up to 98% of food in the meat and seafood category was wasted. As they note, this high figure seems unlikely, and could be due to the fact that particular calculation method uses the amount of money consumers spend on a particular food to calculate waste. Given that meat and seafood are expensive foods, this method of calculation allocates more food waste to this category. We have therefore excluded that calculation method from this graphic. For the other food categories, the results of that calculation method fell within the range covered by the different calculation methods Reutter and colleagues used.

FIGURE 3

Food purchased and wasted in Australia: bakery



(Data adapted from Euromonitor (2019, 2018a, 2018b); Reutter et al 2017)
Note: values are presented in Table 8 of the Appendix (p 37)

FIGURE 4

Food purchased and wasted in Australia: processed and packaged food

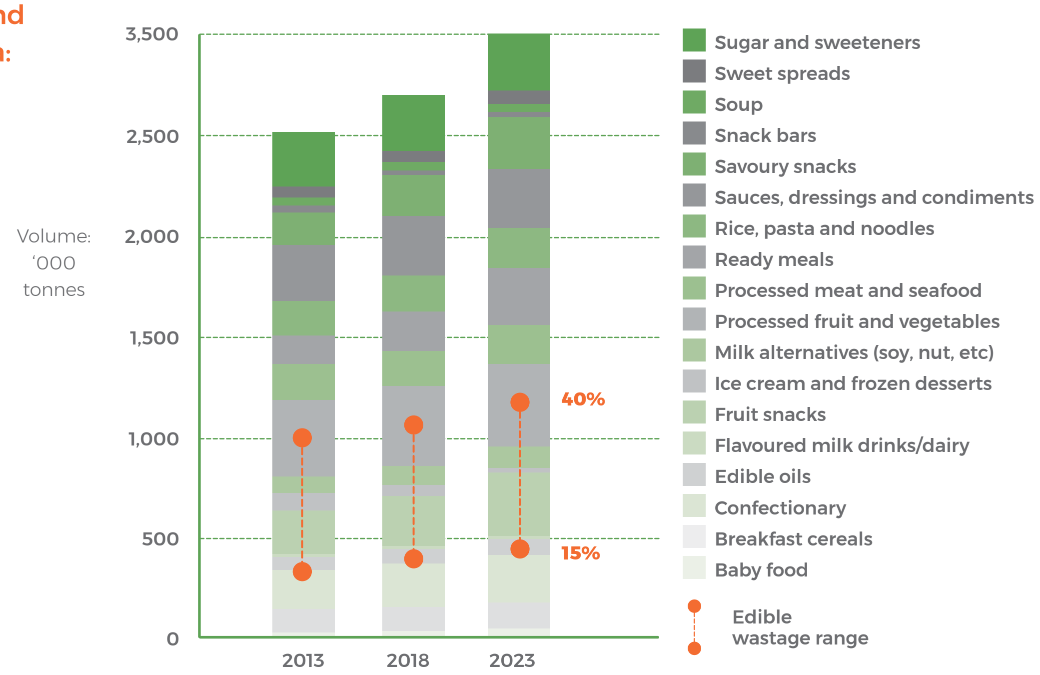
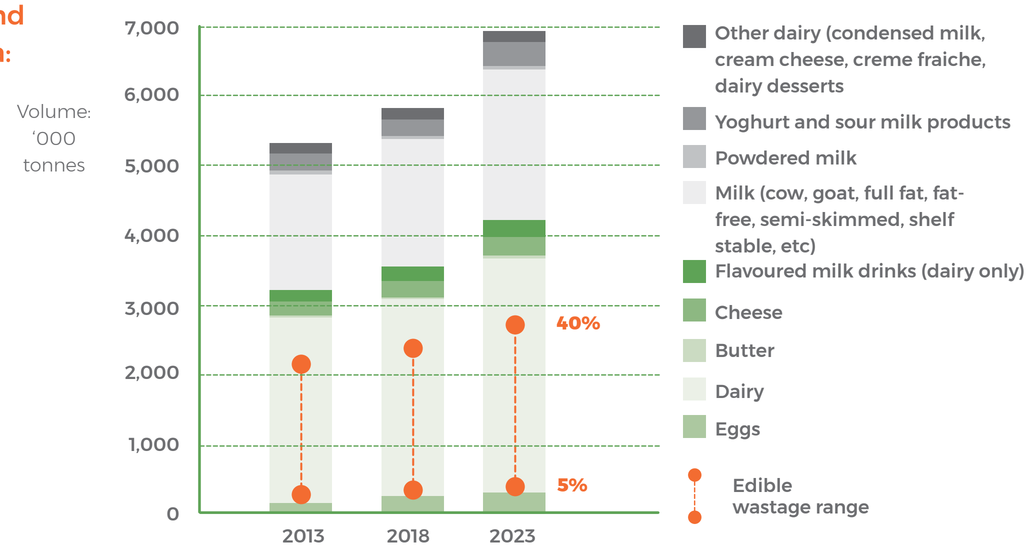


FIGURE 5

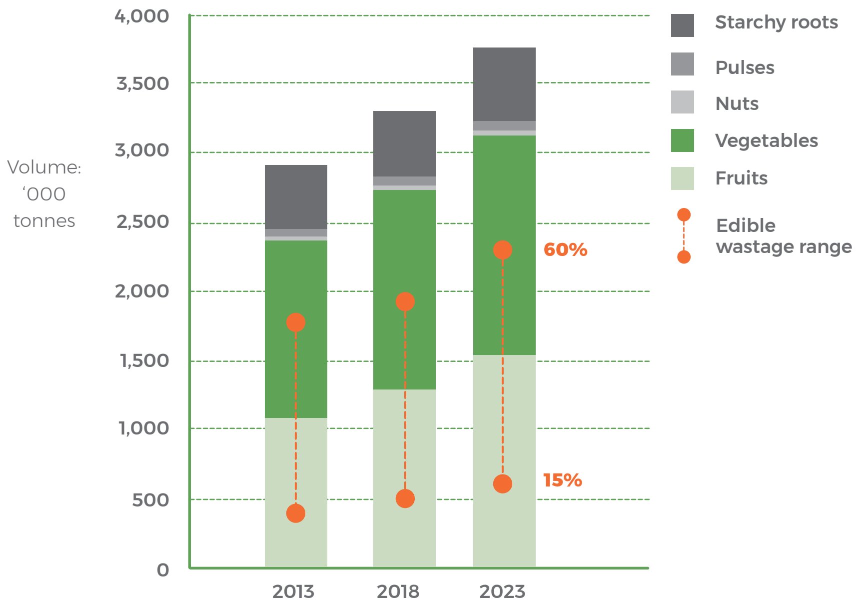
Food purchased and wasted in Australia: dairy and eggs



(Data adapted from Euromonitor (2019, 2018a, 2018b); Reutter et al 2017)
Note: values are presented in Table 8 of the Appendix (p 37)

FIGURE 6

Food purchased and wasted in Australia: fresh fruit and vegetables



(Data adapted from Euromonitor (2019, 2018a, 2018b); Reutter et al 2017)
Note: values are presented in Table 8 of the Appendix (p 37)

The five food categories each represent different levels of energy input and greenhouse gas emissions, which can be identified using a Life Cycle Assessment (LCA). Recent LCA studies have indicated that the growing, harvesting, and processing of mostly grains, fruit, and vegetables have the lowest impact across their lifecycle, and meat from ruminants has the highest impact [46]. Within these categories there are also variations based on plant type, animal type, and geographical location of production.

Table 1, adapted from Clune and colleagues' [46] systematic review of LCA studies for foods that contribute to the five main food categories for this project, summarises the global warming potential (GWP) for different food categories. GWP is measured in kg CO_2-eq/kg produce or bone-free meat. As mentioned above, data collected in Australia about the contribution of different food types to food waste is highly variable, depending on the methods of collection and analysis, however there are percentage ranges available [45], which have been added to the table below.

Considering the LCA for the different categories alongside the data for volumes of food waste in the categories allows us to identify which of the categories might be priority areas for innovation in designing packaging to reduce food waste. For instance, meat and seafood, which has high sales volumes, percentages of waste, and contribution to greenhouse gas emissions across its lifetime (see **Table 1** below), could be a high priority.

TABLE 1

GWP summarised by food type and estimated food waste in respective supply chains

Food type	Global median GWP – kg CO_2-eq/kg *(From Clune et al 2016)*	Contribution to Australian food waste (edible) *(From Reutter et al 2017)*
Bakery and snacks		**10-50%**
Fruit and Vegetables		
Vegetables (field-grown)	0.37	15-50%
Fruit (field-grown)	0.42	20-60%
Passive greenhouse-grown fruit and vegetables	1.10	-
Dairy and eggs		**5-40%**
Milk	1.29	-
Cream	5.64	-
Cheese	8.55	-
Butter	9.25	-
Eggs	3.46	-
Meat and fish		**0-98%**
Fish (all species)	3.49	-
Chicken	3.65	-
Lamb	25.58	-
Beef	26.61	-

Adapted from Clunes et al. (2016); Reutter et al. (2017)

While packaging is often included in LCA studies of foods, Molina-Besch and colleagues [47] have noted that the indirect environmental impacts of packaging in the food supply system, including its role in reducing food waste, are very much underrepresented in the literature.

Various studies have shown types of food wasted most is different across countries, presumably because of "the shopping and eating culture of each particular country" [30 p630]. Age, levels of income, and the number and age of children in a household also impact what type of food is most likely to be wasted [28, 30]. More specific data for the different categories in specific countries can be found in studies conducted by Aschemann-Witzel and colleagues [37], Pearson and colleagues [48], Szabó-Bódi and colleagues [30], and Visschers and colleagues [28]. Food leftovers are identified as commonly wasted in different countries, but food that reaches this stage is outside the scope of this study.

3.3 Existing interventions in household food waste

Food loss and waste solutions are usually aimed at addressing the challenge of food waste through reducing, recovering, or recycling waste. Food waste reduction is seen as the highest value solution [12]. Interventions aiming to reduce food waste in households have included consumer education interventions [12, 49, 50, 51], and technological interventions in household appliances, packaging, and technologies for food planning and sharing [12, 40, 52, 53, 54].

Spang and colleagues [12] argue that existing interventions tend to focus on pressure points for food loss and waste, rather than addressing the broader systemic causes [12]. Their review of existing interventions at the consumer level found that most interventions aim to change consumer behaviour and increase process efficiency, but few involve policy change [12]. They also argue that it is necessary to consider the health and nutritional needs of consumers, and to ensure that interventions aimed at reducing purchases also aim to increase consumption of those same foods. Packaging technologies could have a role to play in reducing food waste by addressing some of the broader systemic causes – such as extending shelf life and maintaining food quality, providing appropriate portion sizes, and using date labelling effectively – without discouraging the consumption of healthy foods. Existing packaging solutions will be discussed further in **Sections 4** and **5**.

Table 2 summarises the existing interventions for reducing household food waste.

TABLE 2

Existing interventions in household food waste

Intervention type	Description
Consumer education	This type of intervention includes: • providing reference and communications material for local authorities to use in promoting reduced food wastage in their local area • advertising campaigns within supermarkets and other food retail stores • supermarket-led social media information campaigns (e.g. on company Facebook pages) • supermarket-led email newsletter information campaigns • intensive consumer training within households to learn skills and practices that prevent waste • changes to consumer 'environments', such as reducing plate or portion sizes
Technological	This type of intervention includes: • consumer tools such as food sharing apps and active or intelligent packaging • refrigerators with cameras inside that are linked to a consumer's phone, so they can check what food they already have when they are shopping • refrigerators that send alerts to consumers via text message or email when food in the fridge is about to expire • colour-coding within the refrigerator assigning colours to particular food types so that consumers are more aware at a glance of what they have in their fridge • increasing the number of temperature-controlled compartments in a refrigerator to account for different refrigeration needs for different foods

Adapted from Bucci et al (2010); Farr-Wharton et al (2014); Ganglbauer et al (2013); Quested & Parry (2017); Spang et al (2019) and van Holsteijn & Kemna (2018); Young et al (2017); and Young et al (2018).

04

‘Save Food Packaging’ and Functional Features

Food waste is generated throughout the entire food chain system, from primary production and harvesting, through processing, manufacturing, distribution, retail, food service, and households. Food packaging plays a vital role across the food supply chain in reducing food waste through functional measures [55]. The sophistication of food packaging is continually advancing shelf life extension and waste reduction strategies. Existing designs and integrated technologies span physical, chemical, sensory, and microbiological protection innovations [56, 57, 58, 59, 60, 61]. There is well-established research on packaging features that extend the shelf-life of food using physical-chemical and microbiological protection. However, research specific into packaging functions that save food from waste ('save food packaging') is considered a young field [36, 59].

This section highlights functional packaging features that save food waste, the causes of household food waste that have already been identified as issues that could be overcome by packaging, and the trade-offs that need consideration with save food packaging.

4.1

Functional packaging features to save food waste

Literature studying the functional properties of food packaging that aim to reduce household-generated food waste is a rapidly growing field. This literature offers multiple definitions for the term 'packaging features' [62, 63, 64] and, at a higher level, multiple definitions of 'packaging functions' [55, 65].

Verghese and colleagues [66] offer a model for understanding packaging functions that through the categories of promotion, information, convenience, utilisation, and waste reduction. These are displayed in the adapted **Table 3**, including examples. In this model, waste reduction is separated as its own category.

TABLE 3

Packaging functions

Functions	Including
Protection	Preventing breakage, spoilage and contamination
Promotion	Describing product features, ingredients and branding
Information	Product identification, product preparation and end-of-life management
Convenience	Preparation and portioning
Utilisation	Providing for transport and retailing
Waste Reduction	Increasing shelf-life

Adapted from Verghese and colleagues (2015); Lewis (2012).

Wikström and colleagues [64] have identified examples of detailed packaging features that specifically aim to reduce food waste generated by consumers. Conte and colleagues [65] classify these packaging features under multiple fields such as high-barrier, multi-layer, or biodegradable attributes. Lindh and colleagues [55] organise the food packaging features identified by Wikström and colleagues [64] under three specific fields concerning the goal of decreasing product waste (DPW):

- protect,
- facilitate handling
- communicate.

The effective DPW protection properties include mechanical, barrier, thermal, and sealing properties. The DPW properties that facilitate handling attributes include features of appointment (dosage), processability, openability, resealability, unpacking/emptying and gripability. DPW communication properties include information placed on-packaging about the food product, packaging, and the combined product-packaging interaction (e.g. digital connectors such as QR codes that provide a cross-over of information concerning food product and packaging systems) [55]. These terminologies have been summarised and merged into **Table 4**, which adapts the packaging functional categories provided by Lindh and colleaguesl [55] and the respective packaging features with the goal of DPW. Similar terminologies and categories have been drawn from landmark publications and industry criteria referenced in the table's footnotes.

TABLE 4

Save food packaging design functions and features identified in literature

Function	Save food packaging design features
Protection	Mechanical protection (high barrier)
	Physical-chemical protection (e.g. multi-layer, modified atmosphere packaging)
	Resealability/Sealing properties
Facilitate handling	Easy to open, grip, dose, and empty
	Processability
	Correct quantity and serving size
Communication	Food safety/freshness information
	Expiry date ('use by'/'best before')
	Storage options information (post-purchase, leftovers)
	Best packaging use information (open, reseal, close, dispense)
	Complete product usage information (recommendations of use)
	Communication on packs about portioning/ material selection/designed functionalities
	Communication on packs (open, reseal, close, and dispense)
	Sorting of household waste information (easy to clean, separate, and fold)
Sustainability design	Criteria and standards (Australian Packaging Covenant Organisation/Sustainable Packaging Guidelines, ISO certification and company credentials, best practice standards).

Adapted from Wikström, Williams, Verghese and Clunes (2014); Lindh et al (2016); Conte et al. (2015); APCO (2019); AIP (2019)

4.2

Reasons for household food wastage that can be overcome by packaging

Packaging-related reasons for food wastage by consumers have been identified in various studies, however there is not yet an agreed upon list of definitions to describe each packaging-related food waste driver [55, 59, 63, 64, 66, 67, 68, 69, 70, 71, 72]. Packaging innovation opportunities are evident when considering the packaging-related drivers of food wastage. These drivers could be considered design failures that have not successfully protected, assisted in handling, or communicated the information to avoid food loss and waste.

Food waste drivers have been collated from the reviewed literature into the first column of **Table 5** [36, 59, 64, 65, 69]. The second column provides related examples of packaging failures or limitations that demonstrate opportunity areas for minimising or eliminating unnecessary food wastage.

TABLE 5

Household food wastage opportunities for save food packaging design

Drivers of food waste	Packaging design opportunities for innovation
Spillage	Inappropriate or difficult to open/reseal packaging design lead to unintentional spill of the product – often by consumers with less strength or control, such as the elderly or young children. Packages that reduce food waste are therefore easy to grip, easy to dose, and easy to reclose.
Over-purchasing quantities	Larger quantities purchased in a weekly shop may not be used. Products bought in higher quantities on sale as a measure that is perceived as cost-effective could be mitigated by packaging design that portions larger quantities.
Excessive quantity per pack	Larger portions in packaging are perceived by consumers as cost-effective and a way of reducing plastic.
Unmet consumer needs/desires	Unwanted product that does not meet the expectations of the consumer
Difficult to empty	Tight corners make food hard to reach; packaging walls hold product rather than encourage emptying

Drivers of food waste	Packaging design opportunities for innovation
Insufficient protection	• Exposure to light, oxygen, moisture, temperature • Tearing, breaking, crushing • Spilling, bursting • Lack of 'tamper evident' features
Expired product	• Forgotten or undesirable food • Date labelling confusion • Inappropriate serving sizes • Information about food safety
Shelf life failure	• Information about how to store • Easy to reseal • Contains the right amount of food • Physical-chemical protection • Packaging material failure – e.g. sealing errors, packaging damage
Reduced product quality	• Physical-chemical protection • Information about how to store • Easy to reseal
Damaged product	Packaging failure
Lack of messaging (category-specific on storage and usage)	Information about how to store

Adapted from Wikström et al., (2018), (2014), (2019); Stensgard and Hanssen (2015); Conte et al. (2015)
Note: authors contributed examples of packaging design (column 2).

4.3

Save food packaging solutions and trade-offs

There are many potential solutions for save food packaging. Protection is viewed as one of the most important roles packaging plays [58, 59, 62, 68, 73]. However, customised portions, sizes, and formatting are also frequently recommended in the existing literature as ways of meeting various household needs and limiting waste. For example, by reducing packaged bread sizes by 30%, the bread packaging would increase by 40% yet reduce the overall environmental impact created by food waste to 1% [59].

Consumer-driven scenarios also need to be considered, particularly behavioural patterns of consumer shopping missions, the frequency of shopping trips, and the drivers of over-purchasing (for example, compulsive purchases, unplanned shopping, and postponing planned meals).

Customised portions, sizes, and formatting are also frequently recommended in the existing literature as ways of meeting various household needs and limiting waste.

Although expanding portioning may be considered as a solution, such as bread loaves available in half and full portions, there is potential for retail FLW to increase if multiple packaging sizes are made available [59].

ReFED [74] recommend improving informative labels and messages concerning freshness, safety, and expiry dates. In the United Kingdom, several recommendations have been made for food packaging labels: only stating a 'use by' date where there is a food safety reason to do so (and use 'best before' otherwise); only having one date label; only stating 'use within x days' where there is a food safety reason to do so; providing clear advice on best storage practices for food, using effective symbols and graphics; and applying consistent chilled storage advice for products that need it [41].

Other technical approaches to shelf life and food quality information are also being explored. These include communicating information through technologies such as radio-frequency identification (RFID), near-field communication (NFC) chips or quick response (QR) codes to improve inventory control, shelf life, or temperature monitoring [66]. For example, Woolworths is promoting a scheduled trial of embedded 2D data codes, such as QR codes, on their internally produced products. This offers an opportunity for further research to test if interconnected information about product and packaging can be contribute to the fight against household food waste.

Trade-offs need to be analysed between the point at which food waste decreases and the level at which the environmental impact of packaging remains acceptable [58, 59]. When considering greenhouse gases (GHG) reduction targets for 2020 and 2025, wasted food is a more significant contributor to packaging in landfill [58]. It is pertinent that ratios differ across food categories when comparing packaging and food waste GHGs (Wikström, Verghese et al. 2018). The Waste and Resources Action Programme (WRAP) [75] suggests that a large amount of food waste can be reduced by food packaging design strategies. However, more specific case studies are needed to demonstrate food waste reduction through packaging initiatives [36, 59, 66]. Consumer perceptions and the likelihood of consumers accepting packaging technologies designed to reduce food waste are also an important consideration. Existing research in this area will be discussed in **Section 5**.

05

Emerging packaging techniques

Food packaging plays a vital role in protecting produce quality through all stages of the food supply system (packaging, distribution, storage, and consumption) [66]. Food packaging technologies are therefore continually evolving to suit supplier demands for extended shelf-life and, arguably most importantly, to satisfy consumer expectations of food quality [76]. This section explores the use of emerging packaging technologies aimed at reducing food waste and discusses how consumers respond to these emerging technologies when purchasing and consuming food products.

5.1

Active, intelligent, and smart packaging to save food waste

Emerging food packaging technologies, commonly known as smart packaging, intelligent packaging or active packaging, is an established industry. Defined by Farmer [77], active packaging "relates to packages that do more than passively contain and protect food, while smart or intelligent packaging senses and informs" [77 p87] the supply chain and/or consumers on the products quality in real time. The 'save food packaging' sector is rapidly growing as a category of this industry, promoted separately by industry bodies that promote smart packaging. For example, the Active and Intelligent Packaging Industry Association [78] includes "fighting waste" among its other smart packaging categories, which also include printed electronics, brand protection, shelf-life extension, augmented reality, mobile commerce, supply chain control, smart labels, condition monitoring, and consumer engagement. Each of these categories have potential to contribute to food waste reduction. This reduction in food waste also aims to reduce the overall environmental impact within food systems, thus enhancing the demand for emerging food packaging technologies [66, 73, 79, 80].

5.1.1

Intelligent packaging

Intelligent packaging is usually presented in the form of sensors and indicators (represented in **Table 6**) that can be scanned at a distance to display the food product's data history [81]. Providing dynamic feedback on the quality, shelf life, safety, expiration date, temperature, and logistics efficiency of food products in real time [66], intelligent packaging eliminates the need for generic date labelling systems.

Additionally, where date labelling presents conservative shelf life estimations due to batch production, intelligent packaging technologies can present quality data on a case-by-case basis. Although this can reduce waste of edible food products that would have been discarded due to an expired date label, Poyatos-Racionero and colleagues [76] stress the importance of retaining food safety. Samples that seem safe but are dangerous (false-negatives) must be avoided. Similarly, samples that seem unsafe but are still edible (false-positives) should be minimised. Reducing time in warehouse and retail storage can act to extend shelf life with consumers while providing a decrease in supply chain spoilage [66, 81].

TABLE 6

Existing intelligent packaging technologies

Type	Description	Save food function
Radio frequency identification (RFID)	Stores product and environment data history	Improves inventory control and rotation
Global positioning system (GPS)	Displays product location history	Consumers can see where their product originated to improve trust
Quick response (QR) codes	Code or image on packaging that can link a consumer to product information	Educates customers on the product (how to store for optimal freshness, nutrition information etc.)
Near field communications (NFC)	Short range connectivity, can be embedded into packaging to transfer information	Educates consumers on how to correctly store the product for optimal shelf life
Image recognition (IR) technology	Using a smartphone to take an image of the packaging, consumers can then be directed to product information	Educates consumers on the product Because no specific code or image is needed to be scanned, consumers are more likely to use this technology over QR
Time temperature indicators (TTI)	Detects mechanical, chemical, electrochemical, enzymatic or microbiological changes in relation to time and temperature	Ensures the product is within the safe temperature range and communicates safety to consumers

Adapted from Barska and Wyrwa, 2016; Verghese et al., 2015.

5.1.2

Active packaging

Deliberately using the interaction between product, packaging and/or the environment produced by the product, active packaging optimises shelf life by controlling chemical, physical, and biological activities surrounding the product. Active packaging can be a complementary addition to traditional packaging or exist as its own unit [82]. This existing packaging technology can be be edible films/coatings, marinades and flavouring, sachets, patches, or tablets [81]. **Table 7** contains examples of active packaging. Benefits of these technologies outweigh associated costs when considering the low environmental impact of the products [66]. Active packaging is widely used in food packaging today as the properties and attributes provide an emphasis on the uniqueness of each product, and so attests to its quality [83].

TABLE 7

Existing active packaging technologies

Type	Form	Save food function	Product use
Modified atmosphere packaging (MAP)	Films	Control oxygen concentration within packaging to limit aerobic microorganisms and oxidation	Meats, fruit, vegetables, cheese, bakery goods
Cryovac® HydroLoQ barrier trays	Trays	Eliminate absorber pad contamination risk, do not absorb nutrients from the meat, increase recyclability	Meats
Skin packaging (Cryovac® Darfresh®)	Trays, film	Remove oxygen to limit aerobic microorganisms and oxidation	Meats, cheese
Oxygen scavengers	Sachets, labels, films, bottle tops	Inhibit oxidation and mould growth, prevent colour change	Oils, fats, bakery goods, roasted coffee, dried fruit
Carbon dioxide scavengers and emitters	Sachets, films	Inhibit micro-biological growth, preventing packaging swelling	Roasted coffee, cheese
Ethylene absorbers	Sachets, films, embedded into paper	Regulate ripening fruit and vegetables	Natural and processed fruit
Antibacterial agents	Sachets, films	Inhibit microorganism growth	Cheese, meat, bakery goods
Antioxidants	Films	Inhibit oxidation processes	Cereal products

Adapted from Barska & Wyrwa, 2016; Crossin et al 2015; Guillard et al., 2018; Pereira de Abreu et al., 2012; Wyrwa & Barska, 2017a

5.2

Consumer attitudes towards active and intelligent packaging technologies

Consumer perception of food packaging largely determines a product's success when implemented into the market as packaging is one of the largest aspects that influence consumer shopping preferences. There is a handful of research that directly investigates consumers' attitudes towards emerging packaging technologies, though none in the parameters of our literature search with a focus on the role of packaging in reducing food waste. In one study, consumers did make an association between a packaging technology and food waste, though they expressed concern that this technology would increase food wastage, rather than decrease it [84].

A common thread within the literature describes consumers' angst towards packaging, specifically plastic packaging, as the highest cause of environmental harm [73, 80, 85]. However, research suggests that packaging represents a small percentage of environmental impact of food systems. Consumers' lacking awareness of this holistic approach ultimately hinders food-saving techniques employed through emerging packaging technologies [66, 80, 81, 83].

Exploring consumer behaviours towards emerging food packaging technologies, a study in Poland identified insufficient consumer knowledge of active and intelligent packaging [83]. Of the 372 respondents, only 17% and 4% were aware of the terms "Intelligent packaging" and "Active packaging" respectively. Further examination of consumer familiarity demonstrated a lack of understanding of packaging technologies, as 53% of respondents had come across interactive indicators before, although they were often unaware that these technologies were present in the packaging [83]. This indicates the need for consumer education of packaging technologies [66, 80, 83].

Common adverse attitudes towards intelligent packaging such as time temperature indicators (TTI) can stem from mistrust that the labels have not been tampered with before reaching consumers, as the labels are not integrated into the packaging [84]. Misunderstanding the labels' colour-reading or contradictions between 'best before' and expiry dates may encourage more food waste [66].

In addition, this confusion may cause consumers to rely too heavily on intelligent packaging, rather than use their own judgment to determine freshness. Crossin and colleagues [81] highlight this difficulty for consumers to correctly interpret TTI readings, and so suggests limiting intelligent packaging technology to business-to-business relationships to avoid confusion and premature food waste.

5.2.1

Positive consumer perceptions

Although the previous section demonstrates a general negative attitude towards active and intelligent packaging, this section discusses packaging technologies that appeal to consumers' demand for food quality, low costs, and low environmental impacts. Vacuum skin packaging (VSP) used to package raw meats is an example of this. The 'no packaging' look and feel of the product visually appeals to consumers as it provides adequate protection from external elements with minimal packaging material. Vacuum skin packaging removes the atmosphere from around the product to decrease microbiologic growth and degradation rates to extend shelf life. In addition to the packaging, marinades (also categorised as active packaging) can be included to further preserve produce. Consumers trust this technology, as it is relatable to common meal preparation techniques, is edible, and indicates quality [81]. Technologies like VSP are low cost, which is not only attractive to consumers but also supply chain industries [76, 81]. While other intelligent and active packaging techniques can be costly, a study in Turkey demonstrates the willingness of consumers to pay up to 10% more for active and intelligent packaged goods, if they understand the added benefits of the technology [86].

A second example of active packaging positively engaging with consumers is the transition from additional oxygen scavengers and moisture absorbing sachets in traditional packaging to incorporating such technologies into the packaging itself. Consumers have expressed their reservations to trust supplementary sachets and pads containing chemicals within food packaging, because of the fear of contamination should a rupture occur.

Incorporating food-saving technologies directly into the packaging bypasses contamination concerns and aims to increase consumer confidence within the role of active packaging techniques [87]. Pennanen and colleagues [84] also found that consumers associated several benefits with TTIs related to an increase in food safety, especially for fresh and frozen seafood and meat and poultry products.

There is a gap in the existing literature for a greater understanding of consumers' perceptions of the role of existing packaging technologies in reducing food waste. It is therefore important to understand the likelihood consumers accepting packaging technologies in order to reduce food waste.

5.3

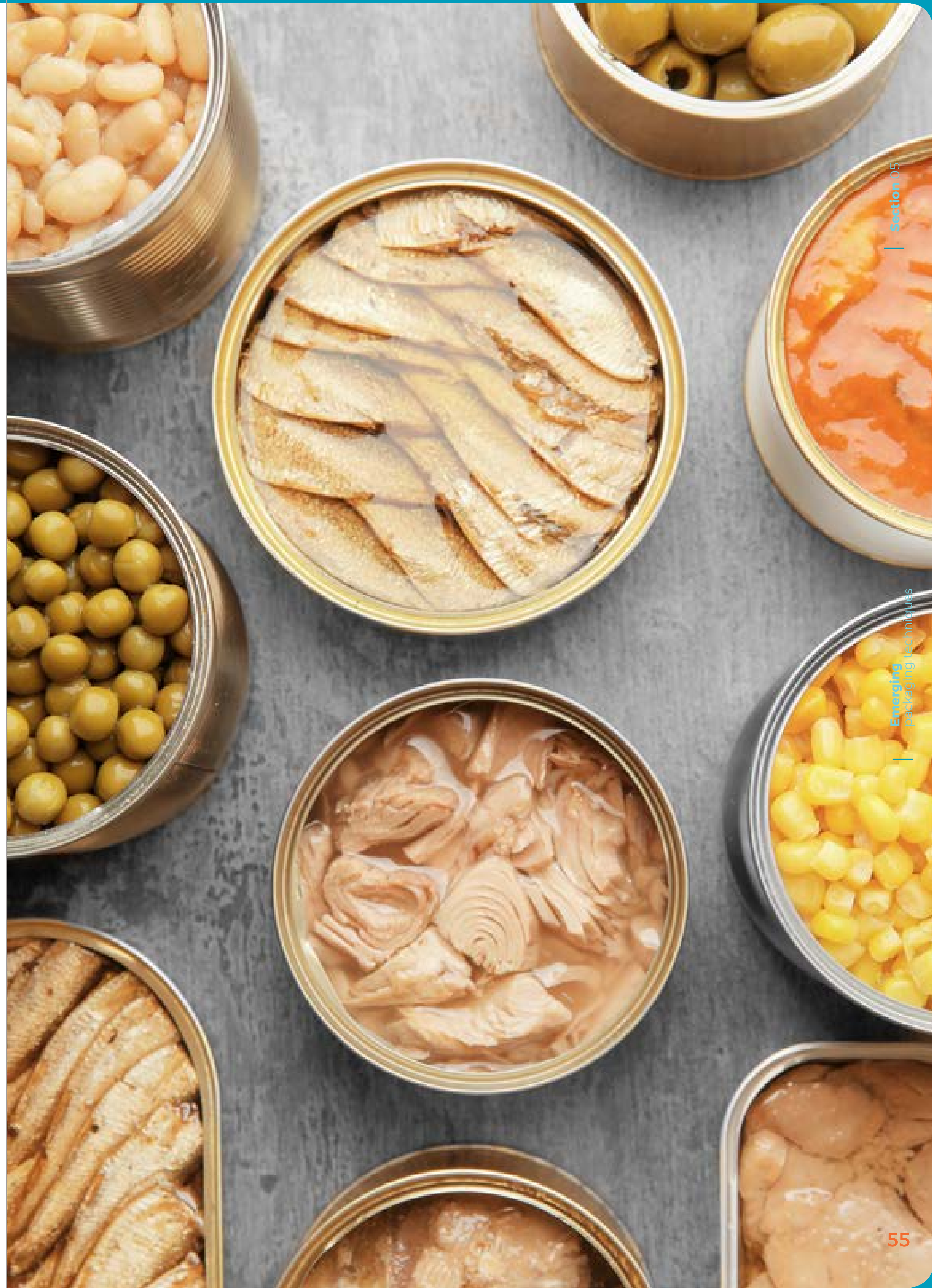
Recommendations for consumer acceptance of emerging packaging technologies

Throughout the literature it is evident that consumer knowledge and levels of awareness, interest, and/or appreciation are major factors in their refusal or acceptance of emerging packaging techniques. The complex relationship consumers have with food packaging creates a barrier to efficient food-saving practices [88]. Educating consumers on the benefits of packaging technologies is repeatedly recommended across the literature [66, 73, 80, 83, 86].

The vocabulary used to communicate with consumers has also been recognised as a concern. Licciardello [73] states that the focus should be on the way the product and packaging work together as a system, rather than simply focusing on packaging. This aims to expand consumers' awareness that packaging is an actor in a food system and is not the only determining factor relating to environmental impact. Consistent research on contemporary consumers' specific behaviours in relation to packaging is required to stay up to date with shifting demands for relevant future design development [83]. Improving packaging design has also been recommended. It is necessary for researchers and industry to have knowledge about the requirements of the food item through the entire life cycle of the product-package combination, uses of produce at key points of its life cycle, and the packaging's function as food protection [59].

The complex relationship consumers have with food packaging creates a barrier to efficient food-saving practices.

Improvements in design also need to identify the aspect/s of packaging design (e.g. portion size, ability to empty) that would reduce waste for specific products [59]. Packaging design can also be used as a medium through which to inform consumers of best practice – for instance, to innovatively communicate portions or information about when the product has actually expired. These factors in packaging design need to be based on the identification of food protection issues for particular products and an understanding of consumer behaviours that contribute to reduced food waste [59]. Finally, studies that explicitly investigate the relationship between food waste and packaging functions in different types of consumer households and in different markets are still needed [36].



06

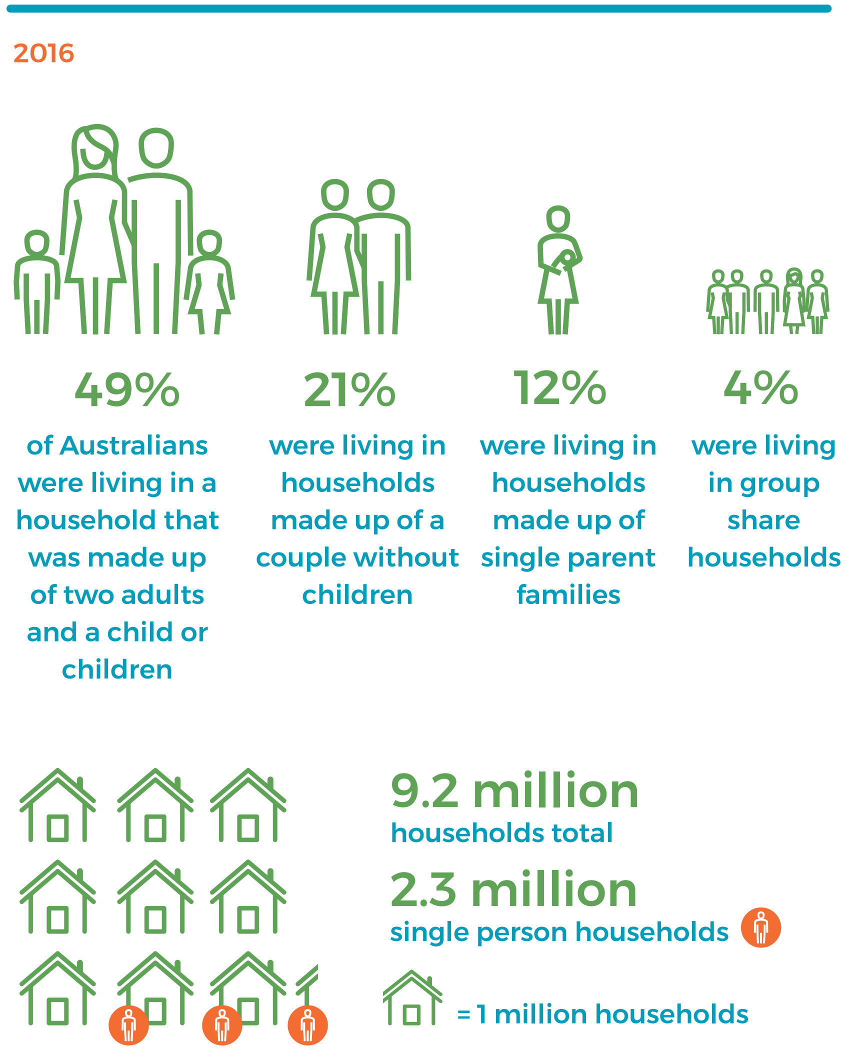
Insights and **recommendations**

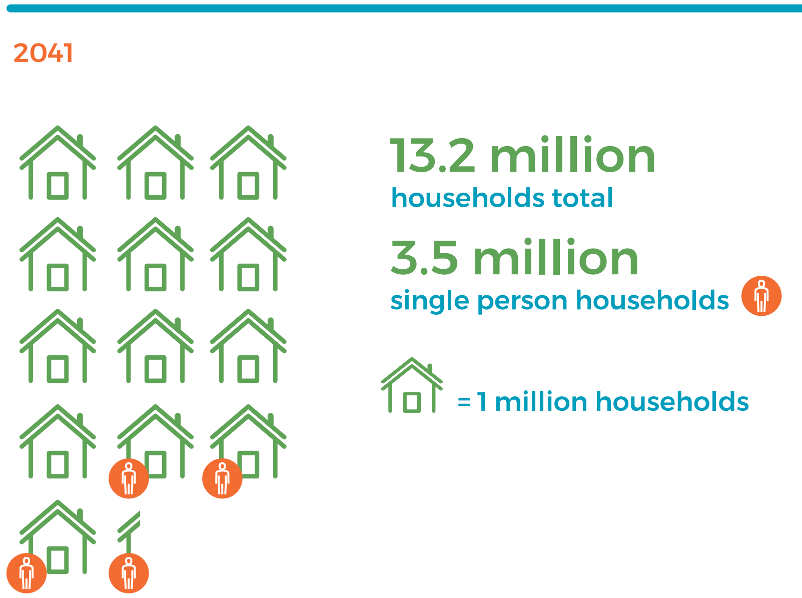
Stakeholders need to co-create solutions to help solve the food waste problem at the consumer stage of the food chain. Technological and packaging design solutions also need to consider consumer perceptions, behaviour, and the likelihood of acceptance. Governments, packaging technologists, designers, marketers, food technologists, procurement agents, and sustainability managers need to collectively be aware of the most important functions, technologies, and strategies to develop a specific product [59]. Systems to enable open access to food loss waste (FLW) data are also required to make this data available to the public as well as research and development communities [59].

6.1 Understanding consumer households and their practices

More research is needed to understand household practices with food packaging and food waste and how these insights can be used to inform product-packaging design. This research will need to understand the ways issues related to packaging and food waste might vary across different kinds of households. In 2016, 49% of Australians were living in a household that was made up of two adults and a child or children; 21% were living in households made up of a couple without children; 12% were living in households made up of single parent families; and 4% were living in group share households [89]. The number of households in Australia is projected to increase from 9.2 million in 2016 to between 12.6 and 13.2 million in 2041 [90]. Food product-packaging system design solutions will need to consider, for instance, the appropriate portion-size for different types of households. For example, single person households are projected to increase to between 3 and 3.5 million households by 2041 – up from 2.3 million in 2016 – and to make up between 24% and 27% of all households – a likely increase from 25% in 2016 [90]. This might mean that more smaller packaging formats are recommended, as has been the case in Sweden [64]. Focus groups and interviews with different types of households could be undertaken to find out about kinds of packaging different households use and what is wasted.

Food product-packaging system design solutions will need to consider, for instance, the appropriate portion-size for different types of households. This might mean that more smaller packaging formats are recommended.





Gale [91] has identified a gap in research about how Australian consumers engage with food packaging solutions such as smaller pack sizes, resealable and subdivided packs, and communication on packaging, making several recommendations for future research. These include that research be undertaken in Australia to investigate:

- broad consumer perceptions of food packaging
- whether larger food packaging sizes and buying in bulk lead to waste in the home
- the storage behaviour of commonly wasted food items in households to identify any link between wasted foods and improper storage of packaging
- how often subdivided packs are chosen by household shoppers
- whether there is a connection between household food waste and misunderstanding date labels
- the need and opportunity for an education campaign around improving the use of date labels on packaging in food management decisions
- how consumers interact with food packaging communication, and where and when on-pack storage information is sought

In addition, we recommend that the following documents are produced from the existing literature, onto which insights from consumer research could be mapped, and the insights then brought back to industry and packaging design:

- A table or mind map of product-packaging formats and reasons why consumers waste them that expands on links identified by Wikström and colleagues [36].
- A priority list for packaging features for specific product categories that draws on the existing literature. For example, for some food categories, portion size may not be the most significant issue and on-pack information or date labelling could be more important. This could be compared with the insights gained from consumer focus groups interacting with packaging samples and with ethnographic research on product-packaging flows in households.
- A product database on format size (portion size) onto which data from households could be mapped to show which packaging formats are used and which formats result in food waste. If smaller portion sizes are available for products that are commonly wasted, households should be asked why those options are not used and/or if it is possible to switch to the smaller option.
- A table or mind map that links packaging features/ technologies to the consumer behaviours and the existing ways of understanding household food waste listed in **Section 3** of this document.

6.2

Consumer education

Future packaging solutions will likely require a level of consumer education. Recent research from the UK has shown that some consumers recognise that food packaging has a role to play in keeping food safe, protecting it during transportation, and extending its shelf life, though a larger percentage are concerned about the impact of packaging on the environment after it is discarded [85]. Since WRAP last surveyed consumers about their perceptions of food packaging, more recognise that packaging has a role to play in reducing food waste. However, the majority of consumers still believe the opposite – that keeping food in its original packaging will make it go off quicker. Most UK consumers were also unaware that food waste is a bigger climate change issue than packaging, with nearly 40% of consumers believing the opposite. Around a third of UK consumers think food waste and packaging are equally big climate change problems [85].

> Most UK consumers were also unaware that food waste is a bigger climate change issue than packaging, with nearly 40% of consumers believing the opposite.

In an Australian context, the need for educating consumers about the role of packaging in reducing food waste is also clear. Ideally this should be undertaken as a partnership between researchers, industry, and government, drawing together the expertise of these different stakeholders. Lockrey and colleagues [4] identified several opportunities for packaging to play a significant role in reducing food waste across the fresh produce supply chain. They make several recommendations for the role of packaging in reducing household food waste of fresh produce in particular, many of which involve a level of consumer education.

Recognising that, like the UK context, there is an increasing negative perception of packaging, they recommend that consumer education should include clear communication on pack that informs consumers on the ideal storage conditions for purchased produce.

Recognising that, like the UK context, there is an increasing negative perception of packaging, they recommend that consumer education should include "clear communication on pack that informs consumers on the ideal storage conditions for purchased produce" [4 p61]. In addition, a better understanding of "the role packaging plays in extending the shelf life of fresh food in the home" [4 p61] and the way some attributes of packaging are designed to help maintain food safety is needed; along with the ways in which features designed to reduce food waste in households is being "missed or misunderstood" [4 p61] by consumers. Lockrey and colleagues recommend that circular economy approaches to packaging could help reduce the negative perceptions consumers currently have of packaging. They argue the reuse of packaging could be "deployed and promoted as extending the value that packaging provides" [4 p61]. This will likely require partnerships between various stakeholders in food supply chains, as well as consumer education. With this in mind, we make the following recommendations about consumer education:

- Testing clearer on-pack communication and date labelling with consumers
- An investigation of what delivery method/s would be appropriate for consumer education campaigns about packaging features (e.g. social media, websites, short videos, infographics) and the level of detail required. This would also require a follow up with consumers to see if their perceptions and behaviours have changed. Such an investigation (and follow up) might make use of a portal on either the Australian Institute of Packaging website or the Fight Food Waste CRC website.
- Incorporating findings around packaging's role in reducing food waste into existing government education campaigns such as the Love Food Hate Waste program.
- Focus groups of consumers interacting with existing and new packaging samples. These focus groups could consider, for instance, whether consumers can identify packaging features that are on the packaging, what they think about those features, and whether any additional features would be useful.

6.3

Using consumer insights to inform industry and develop packaging design

Some research about consumer behaviour and food waste has shown that raising consumers' awareness and providing information are unlikely to be sufficient to elicit a substantial change in behaviour [29]. Instead, engaging with people on a one-to-one basis is effective and allows advice to be highly tailored to the individual [29]. However, this approach is resource heavy. Additionally, as Evans [31] has argued, "responsibilising" consumers can be problematic because it glosses over the challenges consumers face in responding to the "social and material contexts" [31 p430] through which food is provisioned. Indeed, as Evans and colleagues have found [92], recent approaches to food waste have moved to "distinguish between the cause and location of waste" [92 p9] and consider a more distributed responsibility that takes into account the contributions to food waste of other actors in the food supply chain. An approach to packaging design that aims to reduce food waste might also draw on this idea to design packaging that does not solely rely on a large consumer education program to succeed. This would also require industry understanding how consumers use existing products and their packaging. Such an approach would, however, need to seriously consider consumer perceptions and misconceptions of food packaging to ensure a greater likelihood of them accepting packaging designs.

As shown in **Section 5**, existing research that addresses consumer perceptions of packaging technologies is minimal, and there is a further gap in literature that specifically addresses consumers' perceptions of the role of these packaging technologies in reducing food waste. With this in mind, we make the following recommendations:

- An assessment of industry's acceptance of consumer research of perceptions and use of packaging, which would provide an opportunity to see how they can integrate these insights into their packaging design. This could take the form of industry workshops and think tanks.

- Developing an understanding of who in the supply chain benefits from extended shelf life of food and how this might also benefit consumers.
- Standardisation of date labelling and clear communications across the supply chain and to consumers.

6.4

Requirements for packaging end-of-life options

In both the Australian and the UK context, the recyclability of food packaging has been an increasing focus. Nearly two thirds of consumers in the UK said they were less concerned about the negative impact of packaging if it was collected by councils for recycling [85]. In Australia, the Australian Packaging Covenant Organisation has set four packaging targets to be achieved by 2025: 100% reusable, recyclable, or compostable packaging; 70% of plastic packaging being recycled or composted; 30% average recycled content included in packaging; and the phasing out of single-use plastics packaging [9]. As such, Gale [91] recommends that food waste be highlighted as an issue that should be considered in that plan. This would acknowledge product-packaging as a system and include the functions and features of packaging that help reduce food waste as part of product-packaging design. Consumer perceptions of packaging reuse, recyclability, and/or compostability, and the likelihood of acceptability of these packaging options, would therefore be useful to investigate further in this project. In addition, it will also be important to understand potential trade-offs and negative environmental impacts (e.g. more food waste) of packaging material design decisions that compromise product shelf life, for instance in order to achieve the national packaging targets.

6.5

Next steps

This baseline literature review is the first task of the FFW CRC Project — Consumer perceptions of the role of packaging in minimising food waste. The review, insights, and recommendations will be used to inform future activities in this project and other CRC projects. It also provides information for businesses and policy-makers in the food supply chain regarding consumer household food waste and packaging design.

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Find out more about the Fight Food Waste CRC.

Glossary

TERM	DEFINITION
Academic literature	Research papers and book manuscripts that are the result of research from within universities.
Active packaging	Food packaging specifically designed to extend shelf life and maintain quality of products through the advancements of applied packaging technologies and manufacturing processes.
Antibacterial agents	Sachets or films that inhibit microorganism growth within packaging. Commonly used with cheese, meat, and bakery products.
Antioxidants	Films that inhibit oxidation processes within dry goods.
"Apathetic consumer"	The term for a consumer who does not associate any negative feelings with food waste (Amato et al 2019).
Augmented reality	An interactive technology that superimposes a computer-generated image, model, or animation over a real-world environment, activated by a stimulus (e.g. a QR code) and viewed through an enabling device (e.g. a smartphone). Enables an immersive interaction between consumer and packaging.
Boolean search terms	A type of search allowing users to combine keywords with operators (or modifiers) such as AND, NOT, and OR to further produce more relevant results.
Brand protection	Preserving brand and product intellectual property and strategically placing securities (i.e. designs, printed and applied technologies, registers) against risks (e.g. theft, tampering, intended damage, and counterfeiting).
Bulk buying	Buying large amounts of a particular food, perhaps by weight and without packaging, or as the result of a discount promotion.
Carbon dioxide scavengers and emitters	Inhibits microbiological growth through the removal of carbon dioxide.
"Careless food wasters"	A term for consumers who are careless with their attitudes and behaviour towards food waste (Richter 2017).
Complete food chain system	All processes involved in the production and distribution of food products.
Condition monitoring	Supervising conditions products are exposed to along the supply chain to maximise efficiencies.

TERM	DEFINITION
"Conscious consumers"	A term for consumers who consider food waste as a serious problem on a global level, who try to avoid waste in the household, and who feel some level of responsibility for wastage (Di Talia et al 2019).
Consumer education interventions	Interventions that target consumers and aim to provide information about the problem of food waste and changes in daily habits consumers can make to address this.
Consumer engagement	Involving consumers directly in food packaging, aiming to educate about food products and packaging's functions, quality, value, and origin. Also known as digital engagement.
Cooking from scratch	Cooking a meal from all or mostly raw ingredients, as opposed to pre-prepared ingredients such as pasta sauce or curry paste.
Cryovac® HydroLoQ barrier tray	A tray with indentations designed into the base that separates raw meat juices from the meat product, eliminating the need for moisture absorbers.
Disciplined purchasing behaviour	Shopping with a list or buying only what is needed.
Environmental values	Values that attach importance to conserving the natural world and addressing the climate crisis.
Ethylene absorbers	Inhibit fresh produce ripening, therefore prolonging shelf life.
False-negatives	Food that seems safe because it has not yet reached its labelled expiry date, but is unsafe to consume.
False-positives	Food that seems unsafe to consume because it has reached its labelled expiry date, but is safe.
"Fighters"	The term for a consumer who have strong negative emotions associated with food waste (Amato et al 2019).
Fighting waste	The term used to describe proactively and intentionally reducing and/or eliminating food waste.
Food preservation methods	In a household context, these might include methods such as drying, refrigeration, fermentation, canning, pasteurisation, and freezing of food products.
Food retail industry	Grocers, supermarkets, and other sellers of food products.
Food risk	The risk that food will be unsafe for consumption.
Food safety	The extent to which food is safe for human consumption.

TERM	DEFINITION
Food security	When all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their daily needs and food preferences for an active and healthy life.
Food quality	Distinct from any measure of safety, food quality refers to characteristics of food that are acceptable to consumers. These may include appearance, texture, and flavour.
"Forgiving"	The term for a consumer who may have some negative feelings associated with food waste, but who is more resigned and forgiving it (Amato et al 2019).
Global positioning system (GPS)	Provides geolocation and time information.
Global warming potential (GWP)	The potential for a food or other item to contribute the rise in greenhouse gas emissions.
Government partners	Government organisations who have invested in the project.
Grey literature	Materials and research produced by organisations outside of the traditional commercial or academic publishing and distribution channel.
"Guilty"	Consumers who are informed about the impact of food waste and who feel guilty about wasting food (Amato et al 2019).
Image recognition (IR) technology	Software that can recognise food packaging through an image. Used to relay information back to the consumer on specific products.
Improper storage	Storage methods that do not prevent food from going off or being eaten by pests.
Intelligent/smart packaging	Packaging that senses and informs consumers of the product's history.
Leftovers	Cooked food that is left over after a meal and could be eaten at a later time.
Life cycle analysis (LCA)	A technique used to assess the environmental impact of all stages of a product's life from produce growth or raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.
Materialistic values	Values that attach importance to material possessions and the pursuit of personal wealth.
Mobile commerce	The ability for consumers to complete transactions via their smartphone device.

TERM	DEFINITION
Modified atmosphere packaging (MAP)	Packaging that controls the internal atmosphere to extend shelf life of food products.
Near field communications (NFC)	NFC is used to relay information to a receiver from a short distance. Products can be scanned by consumers to gather product information.
"Opulents"	A term for consumers who associate feelings of 'joy' and 'gaiety' with food waste, which could be because surplus food is associated with feelings of abundance for this group (Amato et al 2019).
Oxygen scavengers/absorbers	Sachets that remove or decrease oxygen levels within sealed packages.
Printed electronics	Printed packaging technologies offering higher levels of information for brands, retailers, and consumers, such as near field communication (NFC) chips which can be adhered to, or printed directly onto, packaging labels.
Protection	The role of packaging to protect food products from external atmospheres.
Quick response (QR) code	Code that is printed onto packaging to relay information when scanned.
Radio frequency identification (RFID)	Stores product and environment data history.
Religious beliefs	Beliefs and values that align with one of the world's major religions, e.g. Islam, Christianity, or Judaism.
Rural	Geographical areas located outside towns and cities.
Shelf life extension	Prolonging the time that food is safe to consume.
Shopping habits	Factors such as how often a person shops, whether they use a list, or whether they check what food they already have before they purchase more.
Skin packaging (Cryovac® Darfresh®)	An example of vacuum skin packaging (VSP).
Smart labels	Labels that relay detailed information about the product in real time (i.e. temperature, freshness, time of production, origin). Have the potential to be accessible by supply chain stakeholders, retailers, and consumers alike.
Supply chain	The networked structure of partners and processes involved in the production, management, and distribution of food products.
Supply chain control	Ensuring efficiencies are met within the food supply chain.

TERM	DEFINITION
Technological interventions	Interventions that target some aspect of the technology that is involved in food production, distribution, or storage.
Time temperature indicators (TTI)	Labels that display the quality of the food product (via a colour patch) based on the time packaged and temperatures the packaging has been exposed to.
Unsuitable packaging	Food packaging that is not designed correctly to protect and preserve a specific product.
"Unwitting food wasters"	Consumers who express some concern for food waste, but who are not very informed about its impact (Ricther 2017).
Vacuum skin packaging (VSP):	A form of modified atmosphere packaging (MAP) where the oxygen surrounding the product is vacuumed out leaving the packaging skin tightly wrapping around the product's form. Commonly used for raw meats and seafood.
Willingness to consume	A consumer's willingness to consume a food item.
Willingness to waste	A consumer's willingness to discard a food item.

Appendix

TABLE 8

Food purchased in Australia across the five selected food categories

Food type	2013 Volume: '000 tonnes Value: AUD million	2018 Volume: '000 tonnes Value: AUD million	Projected for 2023 *Volume: '000 tonnes* *Value: AUD million*
Meat and seafood			
Meat	1,913.4 $21,986.7	2,131.0 $22,471.2	2,507.4 $24,954.9
Seafood	266.3 $3,773.0	306.0 $5,976.0	367.8 $7,077.7
Bakery			
Bread (flat and leavened)	675.4 $4,104.0	726.6 $4,797.0	779.1 $4,996.5
Cakes	62.8 $808.4	65.3 $963.9	65.8 $969.2
Dessert mixes	16.4 $149.4	14.6 $147.6	14.1 $142.7
Frozen baked goods	17.2 $88.7	13.5 $72.4	13.3 $65.4
Pastries	44.8 $469.9	58.3 $666.9	66.2 $740.3
Sweet biscuits	103.8 $1,185.8	113.4 $1,372.7	121.1 $1,417.4
Packaged and processed foods			
Baby food	34.0 $573.8	46.8 $1,234.6	56.3 $2,198.4
Breakfast cereals	122.4 $1,211.5	123.3 $1,286.6	136.4 $1,323.9
Confectionary	185.3 $3,761.8	208.6 $4,443.4	238.9 $4965.1
Edible oils	59.7 $474.3	64.4 $564.7	70.8 $607.7
Flavoured milk drinks (dairy with fruit juice)	0.3 0.9	0.2 0.9	0.1 $0.5
Fruit snacks	25.5 $298.5	25.9 $348.5	28.6 $360.0
Ice cream and frozen desserts	215.4 $2,045.7	250.5 $2,683.9	300.1 $3,099.3
Margarine and spreads	86.4 $574.2	50.3 $303.3	22.4 $86.1

Food type	2013 Volume: '000 tonnes Value: AUD million	2018 Volume: '000 tonnes Value: AUD million	Projected for 2023 *Volume: '000 tonnes* *Value: AUD million*
Milk alternatives (soy, nut etc.)	79.6 $194.2	97.0 $295.2	104.5 $350.5
Processed fruit and vegetables	385.2 $1,710.6	395.4 $1,757.9	418.4 $1,647.7
Processed meat and seafood	172.9 $3,119.2	177.7 $3,379.3	187.6 $3,411.3
Ready meals	140.8 $1,670.2	197.5 $2,331.5	284.3 $2,794.3
Rice, pasta, and noodles	181.7 $973.7	187.5 $1,120.3	198.2 $1,174.8
Sauces, dressings and condiments	265.8 $2,456.5	275.7 $2,731.1	297.2 $2,782.4
Savoury Snacks	170.8 $2,871.2	209.5 $3,662.3	252.1 $4,092.3
Snack bars	25.3 $553.7	23.4 $632.6	22.9 $682.0
Soup	46.6 $397.9	41.0 $392.3	39.1 $330.7
Sweet spreads	56.1 $477.5	54.5 $582.0	61.1 $575.4
Sugar and sweeteners	265.1 $1,677.2	270.6 $2,677.7	291.0 $2,815.2
Dairy and eggs			
Eggs	206.5 $1,060.6	258.0 $5,976.0	331.7 $4,163.6

Food type	2013 Volume: '000 tonnes Value: AUD million	2018 Volume: '000 tonnes Value: AUD million	Projected for 2023 *Volume: '000 tonnes* *Value: AUD million*
Dairy	**2,630.8 $10,045.7**	**2,855.9 $11,313.1**	**3,355.9 $12,303.2**
Butter	26.5 $225.1	34.4 $329.4	41.4 $402.9
Cheese	179.1 $2,691.7	195.7 $2,952.1	239.8 $3,060.8
Flavoured milk drinks (dairy only)	180.2 $984.7	233.5 $1,284.6	287.8 $1,335.9
Milk (cow, goat, full fat, fat-free, semi-skimmed, shelf stable etc.)	1,674.6 $2,896.6	1,812.7 $3,291.2	2,148.9 $3,727.1
Powdered milk	6.8 $51.7	7.2 $59.3	7.5 $71.4
Yoghurt and sour milk products	268.1 $1,601.6	307.4 $1,974.4	376.0 $2,404.8
Other dairy (condensed milk, cream cheese, creme frais, dairy desserts)	127.0 $810.5	116.5 $814.6	126.8 $857.3
Fresh fruit and vegetables			
Fruit	1,097.5 $6,255.7	1,297.6 $8,619.0	1,546.2 $10,023.1
Vegetables	1,278.6 $9,992.4	1,440.0 $13,179.4	1,586.3 $14,667.6
Nuts	17.8 $139.7	23.2 $238.5	27.9 $286.2
Pulses	67.2 $285.1	73.6 $317.2	82.8 $360.7
Starchy roots	452.3 $1,031.0	470.0 $1,033.7	511.5 $1,144.4

Adapted from Euromonitor (2019, 2018a, 2018b). See Figure 2 through to Figure 6 for visual display of these values

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About this project

Understanding the perception and use of packaging by consumers and how this plays a role in household food waste generation is an important first step in this project. With a greater understanding of how people appreciate and use packaging, along with the food waste they generate, we can design improved packaging and communications on food waste avoidance that will ultimately reduce food waste.

This project aims to understand consumer perceptions of the role of packaging in reducing food waste by:

- discovering target areas that will help drive packaging design decisions.
- discovering key consumer behaviours that may be adapted to reduce food waste.
- determining potential consumer responses to labelling and packaging alternatives in relation to food packaging.
- providing formative information for partners' new product development processes.
- designing packaging solutions to reduce food waste.
- designing more effective consumer education campaigns to reduce food waste.

The Project Partners are:

RMIT UNIVERSITY

Sustainability Victoria

Woolworths The fresh food people

fightfoodwastecrc.com.au

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Cooperative Research Centre
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