

Article

A Pilot Study on Industry Stakeholders' Views towards Revalorization of Surplus Material from the Fruit and Vegetable Sector as a Way to Reduce Food Waste

Shelley Fox ¹, Owen Kenny ¹, Francesco Noci ² and Maria Dermiki ^{1,*} 

¹ Department of Health and Nutritional Sciences, Faculty of Science, Atlantic Technological University, Ash Lane, F91YW50 Sligo, Ireland; shelley.fox@research.atu.ie (S.F.); owen.kenny@atu.ie (O.K.)

² Department of Sports Exercise and Nutrition, School of Science and Computing, Atlantic Technological University, Dublin Road, H91T8NW Galway, Ireland; francesco.noci@atu.ie

* Correspondence: maria.dermiki@atu.ie

Abstract: Food waste is a global issue, with the fruit and vegetable sector accounting for higher losses compared with other sectors. The aim of this study was to gain an understanding into how industry stakeholders in Ireland manage surplus fruit and vegetable material remaining after their main processing. An explanatory sequential mixed methods approach was employed to collect data in the form of online surveys (n = 55) and one-to-one interviews (n = 7). The findings outlined several barriers to revalorization. Most respondents were measuring food waste and actively trying to minimize it, although this was for economic rather than environmental sustainability reasons. Environmental sustainability measures were an important factor for larger companies, although all respondents agreed it was important to manage this material from an environmental perspective. This material was mostly classified as “food waste” and usually composted or used for animal feed. Many stakeholders had identified opportunities for revalorization; however, for smaller businesses, this cannot become a reality without considerable investment. Joined-up thinking is required among all stakeholders, including consumers and policy makers, to create positive sustainable changes. Education and greater awareness about the extent of the food waste crisis may assist in achieving reduction targets and encourage revalorization in the industry.

Keywords: food loss; sustainability; surplus material; waste management; mixed methods



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1. Introduction

Food waste is a global issue, impacting not only economic factors but also social and environmental [1]. Globally, a quarter of all food produced do not reach our tables [2,3]. To address this and other global issues, the United Nations has developed the sustainable development goals (SDGs), with SDG 12.3 specifically aimed towards a 50% reduction in overall food waste by the year 2030 [4]. In Europe, in order to achieve this target, a number of proposals have been adopted by European Union (EU) member states as part of the EU's Farm to Fork strategy, which at its center focuses on achieving a “fair, healthy and environmentally friendly food system” [5]. This process will not be without difficulties and will require the collaboration of all stakeholders across the food supply chain.

The first step in reducing food waste is accurate measurement. However, this has been challenging due to the many definitions of what constitutes food loss and waste, respectively [1,6]. According to the Food and Agriculture Organization (FAO), food loss is mostly associated with primary production and early stages in the food supply chain, while food waste is considered as happening at the latter stages of the supply chain, particularly at the retail and consumer stages [1]. The definitions varied considerably in the EU Fusions project [6], which included edible and inedible waste material and categorized all material as food waste. It also did not classify material that goes to biorefineries or for animal feed

as waste or loss [6]. These subtle differences in definitions from study to study have been recognized as creating a barrier to accurate measurement and implementation of food waste reduction practices [7,8].

Other factors to consider in the classification of food waste and losses are food surplus and by-products. Food surplus refers to food that is produced in excess to meet potential orders that may never be realized. This phenomenon is threatening food security and generating food waste that could be avoidable [9,10]. By-products are specific materials that are generated during normal production practices but not required in the finished product and potentially discarded [11], like the peels and trimmings of vegetables discarded when preparing a soup mix, for example. With all these factors to consider, it is understandable how measurement can be difficult. Further classification could be required to identify what element of food surplus is potentially avoidable or categorically unavoidable.

In Ireland, the Food Waste Charter is a voluntary agreement led by the Environmental Protection Agency (EPA) that has measurement protocols to guide businesses in (i) identifying where waste is occurring and (ii) providing suggestions for how to avoid this waste [12]. The most recent Irish figures show that approximately 770,316 tons of food waste were generated across the food supply chain, with 31% coming from households, 29% from processing and manufacturing, 23% from hospitality and 9% from primary processing [13]. While fruit and vegetables may only account for a small quantity of food overall, they generate a considerably larger amount of food waste: 76% (fruit) and 41% (vegetables) across the supply chain [14]. Irish figures also confirmed that the largest contributor among primary processing industries was horticulture [14].

The food waste hierarchy [15] is used as a tool to understand the different ways in which food waste can be managed, with prevention the primary objective and disposal to landfill the least preferred option. This has been adapted in many studies to provide a clear direction for utilizing this material in beneficial ways to reduce food waste, such as re-using it for animal or human consumption and recovery of nutrients, as well as energy or revalorization of by-products [8,9,16].

Naturally, food producers have always considered using by-products or side-streams and creating new routes to market to improve profitability [17]. To date, the most popular method for using the waste material from the horticulture industry is as animal feed [9]. Recycling food waste into animal feed is positioned in the center of the food waste hierarchy after all measures have been exhausted to keep food in the human food supply chain [15]. Many horticulture farmers also rear animals; therefore, using this material as animal feed is a cost-effective way of managing surplus material [18]. It is also important to consider that if food waste is to be brought back into the human food supply chain, it may require further treatment or storage space to allow waste material to be held and used safely [19], which could be outside the smaller growers/farmers' capability in terms of infrastructure. Biomass conversion is a method that has been explored for managing excess loss or waste, not only from the horticulture sector but other sectors as well, and constitutes the recovery stage of the food waste hierarchy which treats unavoidable food waste [9,15]. This is a relatively new process, but research indicates it could be a lucrative one with the generation of value-added biobased food and feed ingredients [20,21]. Studies have also shown that waste material, such as the shells of nuts [22] or onion peels [23], can be used in the production of bio composite films with improved mechanical properties. Numerous studies have been conducted focusing on the extraction of bioactive compounds from fruit and vegetable waste streams, mostly on a small scale but with clearly demonstrated applications in both the food industry and cosmetic industry [19,24–35]. However, due consideration should be given to the cost of setting up biorefineries or purchasing new equipment for the extraction of functional ingredients from side-streams remaining after normal processing, as costs may be prohibitive [19,31,36]. The availability and the quality of the waste material present should also be considered, as factors like seasonality could impact this material negatively. It may also require treatment to avoid spoilage before going through revalorization, and this could cause the cost to spiral [26]. Time may also

be required to find new markets for new functional ingredients, and new biobased foods may need to go through novel food legislation before being eligible for sale on the open market [36]. However, this effort could be valuable, particularly due to the quantity of waste generated from fruits and vegetables which results in nutrients being lost from the supply chain [25]. Bringing nutrients such as water-soluble vitamins and dietary fibers, along with phenolic compounds, back into the supply chain through waste valorization could add value and improve sustainability [25,27,37]. This method of waste valorization is often referred to as “circular eating”, as it creates a circular process, using all of the surplus material where possible and avoiding food waste [38–41].

The literature identifies the exploration of fruit and vegetable waste valorization as a sustainable means of managing food waste but also demonstrates several barriers, mostly linked to economic factors such as scaling up processing. A review of the literature so far indicates information on volumes of food losses in primary production [14] and food waste across the supply chain [13], but there is a lack of information on current management practices of industry stakeholders in Ireland.

Therefore, the aim of this research was to identify stakeholders’ current management of surplus fruit and vegetable material remaining after processing and what factors influence their decision to revalorize this surplus material. To satisfy this aim, the following research questions were employed:

Q1. How do stakeholders currently manage their fruit and vegetable surplus material or by-products?

Q1(a) What factors influence management of surplus material by the companies?

Q1(b) What types of product(s) if any, do the stakeholders have surpluses of?

Q2. What are the barriers or drivers impacting stakeholders’ decision to add value to surplus material generated from the fruit and vegetable sector?

2. Materials and Methods

2.1. Methodology

The term stakeholders in this study refers to companies along the food supply chain working with fruit and vegetables: for example, farmers, wholesalers, food processing companies, restaurants, cafes and retail supermarkets.

An explanatory sequential mixed methods approach was employed to collect data from stakeholders on their current management of surplus fruit and vegetable material remaining after their main processing [42]. This was in the form of an online questionnaire, followed by semi-structured one-to-one online interviews that helped further explain the findings from the surveys. Quantitative and qualitative data provided reliable, valid and comprehensive information resulting in a more detailed understanding of the issues and the potential for circular eating through waste valorization in Ireland, where currently there is a lack of information. This study was approved by the Research Ethics Committee of Institute of Technology Sligo, Ireland in December 2021 (Reference No: 2020048, part 2).

2.2. Survey Design

The survey was developed using Qualtrics XM (first release 2005, copyright year 2021, US, available at <https://www.qualtrics.com>, accessed on 22 February 2022), and it was structured in a way to answer the research questions (Q1 and Q2). The survey was divided into four sections. The first section collected background information about the stakeholder, for example, the type and size of each stakeholder. The second section focused on the types of surplus material present, whether measurements are usually recorded, and if so, what the estimated annual quantities are. Surplus material was defined as any fruit or vegetable material remaining, after normal manufacturing operations are concluded. The survey respondents were then asked to read statements in relation to the management of surplus material in their business and rate how much they agreed or disagreed with each statement.

After these sections, the focus was narrowed to the fruit and vegetable surplus material present, how the respondents classified this material, if they had considered adding value

to this material, and if not, how they currently deal with this surplus material. The question grid that presented each question and justified the reason for inclusion in the survey based on the literature can be viewed in the Supplementary Material (Table S1). A link to the survey can be found here: https://itslgo.fra1.qualtrics.com/jfe/form/SV_25nlpyPUoFKSBim, accessed on 28 March 2022.

Those who completed the survey were asked if they wanted to progress to a one-to-one semi-structured interview, which was conducted and recorded through online videoconferencing platforms (MS Teams or Zoom). The interviews followed a format similar to that of the survey, firstly collecting some introductory information about the stakeholder and then asking questions related to the measurement of surplus material. This was followed by questions on the types of surplus material present and questions related to valorization of the surplus material. Then, the respondents were asked about the perceived benefits or barriers to valorization. Finally, the stakeholders were informed about the SDG 12.3 target goal of reducing food waste by 50% by the year 2030 and asked about their knowledge of this target and their belief that it was achievable. During both the survey and the interviews, if a stakeholder answered no to certain questions, for example, “no I have not identified a side-stream”, they skipped to the next relevant question for them. The question grid including the questions used for the interviews, along with the justification, can be seen in the Supplementary Material (Table S2). Both the interviews and survey were piloted before going live with stakeholders.

Stakeholders were purposefully recruited for the survey and interviews, to achieve sample triangulation (Figure 1) by advertising the study via organizations like the restaurants association, Enterprise Ireland (EI) and the Local Enterprise Offices (LEO), Irish Business Employers Confederation (IBEC), the Farmers Journal and social media platforms (LinkedIn, Twitter, Facebook). Snowball sampling was also employed for recruitment purposes to increase awareness of the study [18,43].

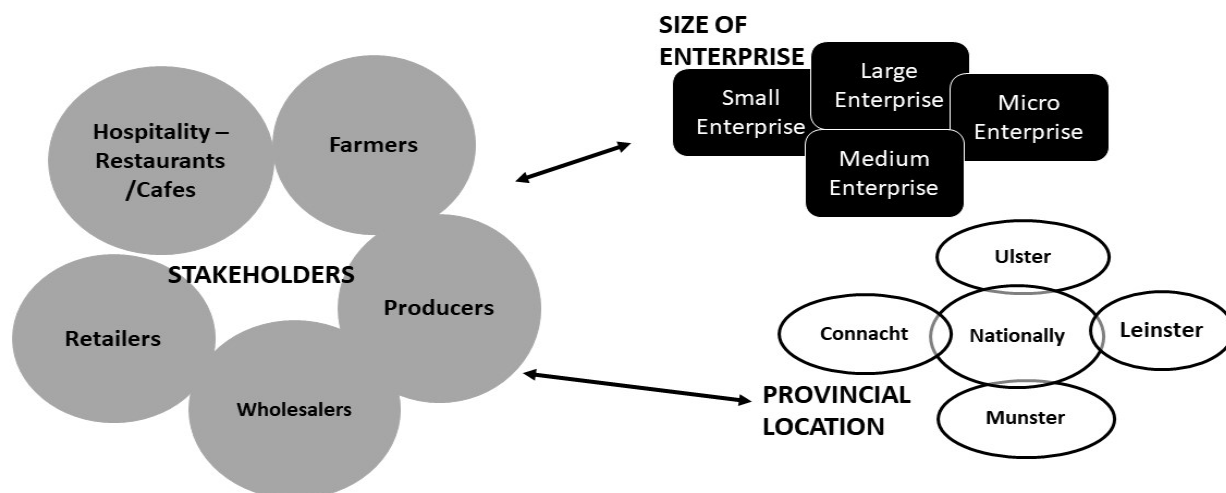


Figure 1. Sample triangulation employed in this survey to capture all stakeholders, from small and large enterprises across all provinces within Ireland.

2.3. Data Collection and Analysis

2.3.1. Survey

There were 55 responses to the survey. Within these responses, all criteria of the sample triangulation were met (Table 1). Most participants were from the Leinster region of Ireland, where a high percentage of growers are based. Most respondents ($n = 22$) were from large companies (>250 employees); however, all company sizes were represented in the study. The surveys were mostly completed by respondents who identified as owners or managers of the individual stakeholders. The survey results were analyzed using descriptive statistics using SPSS version 28.0 (IBM Corp. Released 2022. IBM SPSS Statistics

for Windows, Version 28.0, Armonk, NY, USA, IBM Corp). Descriptive statistics were used to outline the frequencies of the responses, and cross tabulation was conducted to present the responses across the different stakeholders. The level of agreement scale was collapsed from five points—strongly disagree, disagree, neutral (neither agree nor disagree), agree, strongly agree—to three points as follows: disagree, neutral (neither agree nor disagree) and agree.

Table 1. Number of participants in each of the stakeholder groups that completed the survey and the interviews.

Stakeholder	Survey Participants (n = 55)	Interview Participants (n = 7)
Primary Producer (Farmer)	6	2 ¹
Wholesaler	9	1 (+2) ¹
Secondary Producer (Food Processor)	14	(2) ¹
Retailer	3	2
Hospitality (Restaurant/Café)	12	2
Other	11	0

¹ The two farmers interviewed also have a wholesale and food processing side to their operations.

2.3.2. Interviews

Seven interviews were conducted with participants representing each of the stakeholders identified; these participants had also completed the survey. The farmers interviewed also had a wholesale business and processed prepared products for the food service industry, thus representing more than one stakeholder category. The recorded interviews were transcribed verbatim using Otter transcription (version 3.30.0-90c819b7, US, available at <https://otter.ai>, accessed on 8 July 2022). To ensure accuracy, the interviews were listened back to on two separate occasions, and the transcripts amended as required. The data were coded and analyzed into themes using reflexive thematic analysis (Braun and Clarke, 2006, 2020, 2021); this was managed using Microsoft Excel. See Supplementary Material for a sample of the coding process employed (Tables S3 and S4).

3. Results and Discussion

As this was an explanatory sequential mixed methods study, the results of the survey and interviews are presented together. The interview responses inform the quantitative findings from the survey. This section begins with how the stakeholders manage fruit and vegetable surplus materials in their business right through to their views on revalorization of this material.

3.1. Measurement and Management of Surplus Material

Most survey respondents (n = 52) confirmed they do record the amount of surplus material present in their companies, with the majority reporting <10,000 tons of surplus material present per annum. Most respondents (n = 17) stated that fruit and vegetable material made up 76–100% of this tonnage, with wholesalers the highest contributor (n = 7). These volumes are in line with current reports in relation to fruit and vegetable losses from FAO's 2019 the state of food and agriculture report, where they state, "it is not surprising that fruits and vegetables incur high levels of loss given their highly perishable nature" [44].

The findings from this survey show that 20% of the stakeholders are composting their surplus fruit and vegetable material, 13% are segregating it into brown bins for collection by a third party, and 13% are using anaerobic digestion to manage the surplus material. A small percentage of survey respondents leave surplus material in the field to decompose or use if for animal feed, but unfortunately, there is still a reliance on disposal to landfill, with the results showing 15% of participants using this option. A very small percentage

(4.5%) of survey respondents stated they are currently using all of this material in a side stream ($n = 2$). Figure 2 shows a more detailed breakdown of food surplus management by stakeholder; for example, the stakeholders who are using all of their surplus material in the side streams are represented by a secondary producer and a company who identified as "other", explaining they are both a primary and a secondary producer.

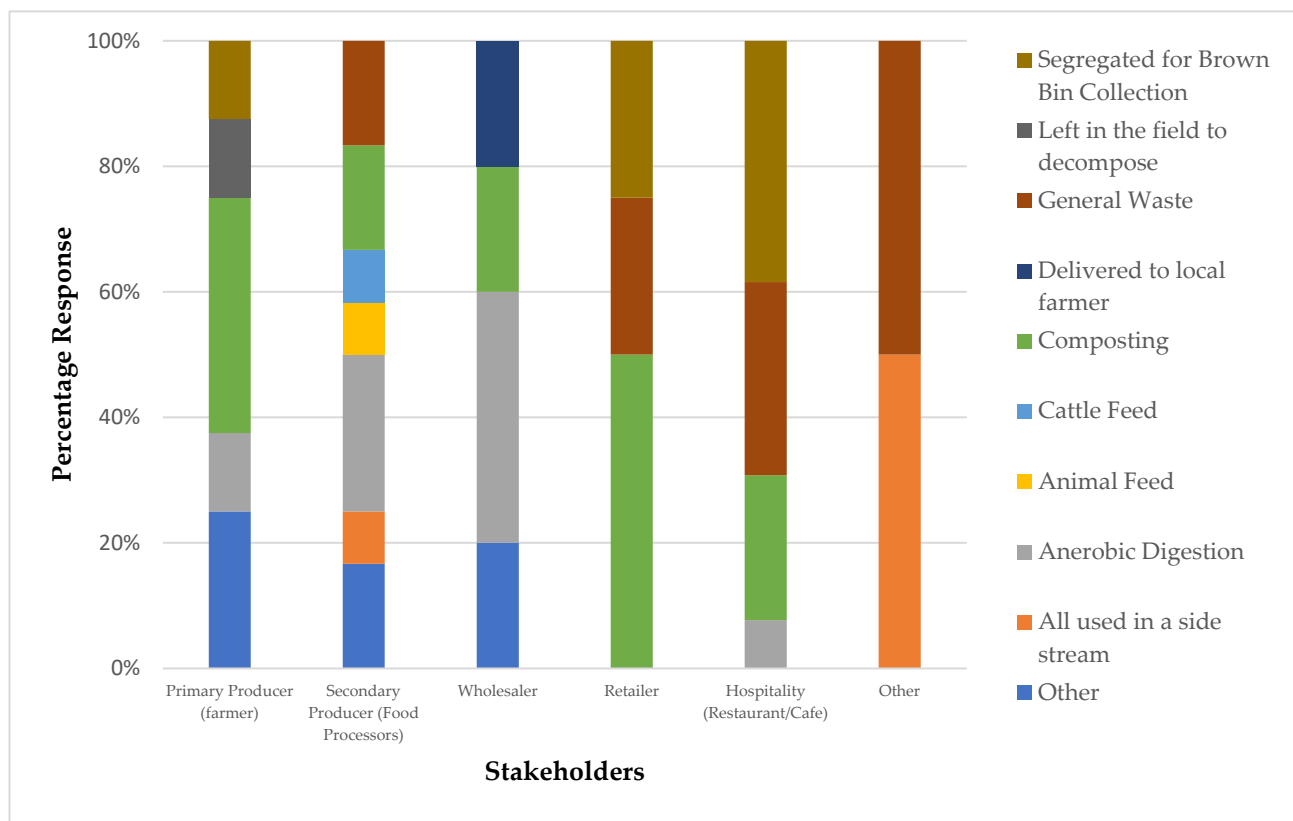


Figure 2. Current practices employed by each stakeholder to manage their surplus fruit and vegetable material (figures taken from survey respondents).

The current management of surplus material is varied. Composting is the most popular method employed by representatives from all stakeholders ($n = 11$). However, as mentioned, general waste with disposal to landfill is also still evident, particularly in the hospitality sector (Figure 2). As anticipated, it is the primary producers who leave surplus material in the field to decompose; this was also evident in the literature mostly to avoid excess costs associated with harvesting produce that does not meet customer specifications [18]. In the stakeholders' survey, the low number of respondents using surplus material for feeding animals was surprising, whereas other studies found this to be the most popular method for managing surplus material [9,18]. It was anticipated that secondary producers and wholesalers would be the main stakeholders using this method to manage their surplus material. Indeed, this was evident in the interviews, where the wholesalers confirmed they segregate waste material for transport to farmers for animal feed or to feed their own animals. Anaerobic digestion ($n = 7$) was used by primary and secondary producers and wholesalers mostly, while segregation for brown bin collection ($n = 7$) was mostly used by the hospitality and retail industries.

In the interviews, stakeholders acknowledged that they dispose of surplus material in ways similar to the practices found in the survey responses, as shown in Figure 2, often managing this material in a way that is convenient for the company's access to various options, such as composting or segregation for animal feed. It was suggested that measuring the surplus material is part of standard operating procedures connected with forecasting and planning. It is mostly completed for economic reasons, as waste generated leads to loss of

sales, which need to be quantified. The larger businesses have built-in sustainability factors in their business models which they categorized as "sustainability credentials". These factors are linked to attaining origin green status, which is an independently audited, national program that allows the industry to incorporate measurable "sustainability targets" within their business that consider the environment and local communities [45]. Measurement of waste and surplus material would be one of the metrics they are measuring, as the quotes below explain.

"For sustainability credentials, and there is a reporting structure behind everything that we do" **Large Wholesaler**

"It's part of weekly, quarterly, and annual KPIs that we will manage food waste, it's tied to profit and loss. We would have liked a margin that the department will have to hit every week" **Retailer.**

Figure 3 details the stakeholders' perspectives on the challenges presented when managing surplus material from the fruit and vegetable sector specifically. Wholesalers and retailers mostly agree that managing surplus material is an ongoing challenge. There was, however, a difference of opinions among the primary and secondary producers as well as among the hospitality sector respondents, with some more comfortable managing this surplus material than others. All stakeholders participating in the survey agreed that it is important to manage food surplus from an environmental perspective (Figure 3). This study revealed that consumer expectations were more relevant to secondary producers, retailers and the hospitality sector. However, Göbel et al. [46] highlighted that factors such as consumer expectations can have a knock-on effect across the whole supply chain. The retailers in this survey were well-informed on how to manage food surplus effectively; however, the other stakeholders did not share this opinion and believed there was a lack of information available to them. The reason for this difference in opinion could be down to the fact that many retailers have had processes to mitigate food waste in place for some time now, such as discounting produce which is near its "best before" date [47]. However, this often moves the food waste problem onto the consumer stage. Figure 3 also shows that most stakeholders surveyed believed there was enough time within their individual day-to-day operations to manage food surplus effectively, apart from the primary producers and hospitality sector. This was further explained in the interviews when these stakeholders highlighted the short timeframes available to them in their day-to-day operations that hindered accurate management of surplus material, as the quotation below from a small café owner explains.

"I suppose the big thing would be not having time to process things, because you only have a certain window, you know, you have a fresh thing. You know, if you have to make things that are being sold immediately, you know, that that's the priority." **Hospitality (café owner/manager)**

The respondents from the interviews explained why food surplus generation can be challenging, alluding to time as mentioned and the impact of inconsistent labor practices, particularly among secondary producers and retailers who found it difficult to retain staff. This was mostly due to the nature of the work, as the quote below explains.

"It's getting harder to get people to do particular jobs like peeling and preparing difficult veg like turnips, it's very hard laborious work" **Family business—wholesaler/farmer.**

COVID19 was also a major disruptor for the food industry, with competent staff lost due to uncertainty in the sector at the time. The companies interviewed acknowledged they are still struggling to get back on track as a result. They also highlighted a need for investment in equipment and facilities to improve process efficiency, which is needed to manage surplus material more efficiently.

"It's either big investment or we need to stop what we're doing" **Family business—wholesaler/farmer.**

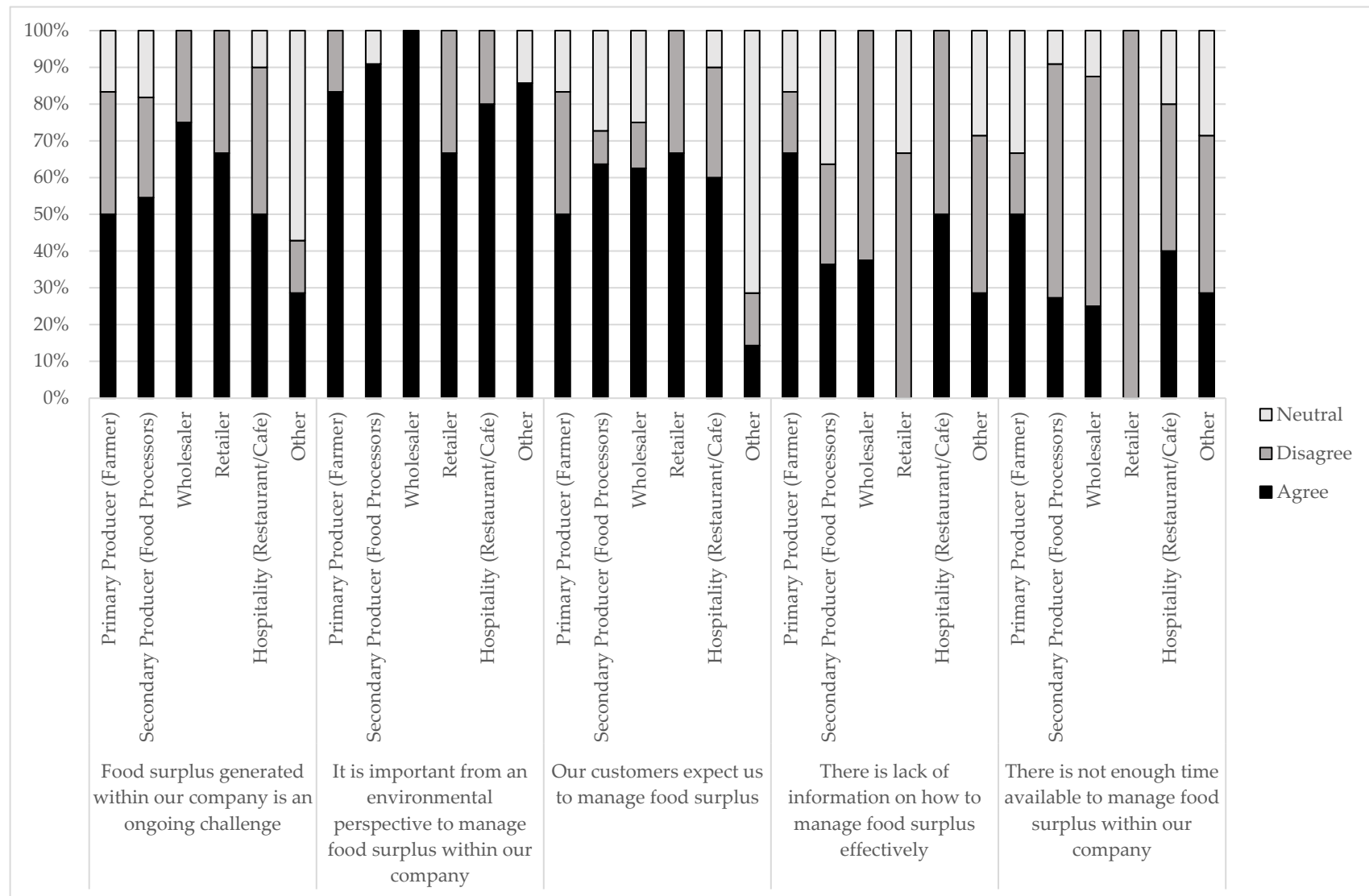


Figure 3. Results from survey focusing on statements connected with managing food surplus material generated from fruits and vegetables.

All of the stakeholders interviewed recognized this is an area that needs to be addressed, not solely from an environmental perspective but also to ensure their business models remain viable. Some of those interviewed felt they should take more of a leadership role in educating their customers. Even though they believe consumers are more aware in general, they themselves were not promoting the good work they are doing to create "zero waste kitchens", for example.

3.2. Classification of Surplus Material

The survey included a question relating to the classification of surplus fruit and vegetable material after participants were provided with the definition of food waste and food loss according to FAO [48]. This was asked to help gain a better understanding of how the stakeholders view this material, which would explain current management practices. The results showed that many respondents ($n = 23$) classified this material as "food waste", a high proportion also identified this material as "animal feed", and a small number ($n = 5$) classified this as "material for further processing". Breaking this down further to individual stakeholder sectors, the hospitality stakeholders mostly classified this material as food waste. Secondary food producers mostly classified it as material for animal feed. Primary producers (farmers) classified the material as either food losses ($n = 3$), food waste ($n = 2$) or product left in the field that did not meet specifications ($n = 1$). One retailer defined this material as donations. Donations would be a popular option for retailers managing surplus material across all of their produce, not only fruit and vegetables, with Irish companies like Food Cloud collecting the surplus and redirecting this valuable commodity to those in need [49].

The stakeholders' interviews conducted further explained the findings of the survey showing that stakeholders with numerous remits within their business model were able to use surplus for animal feed. For example, two of the interview participants were farmers who not only grow produce but also raise animals (cattle), making animal feed a beneficial management practice. The larger wholesaler interviewed also had an agreement with local farmers to collect surplus material for animal feed. However, composting was a common way of managing the remaining surplus material for all of those interviewed. The general view was that if another use for the surplus material was found, then it was not classified as waste. This is like the EU Commission's FUSION [6] definition, which differs from the FAO [1,48] definition in that it also considers inedible material. Oliveira et al. [50] confirmed with a review of papers from 2011–2020 that "there was no specific concept for food losses and waste which made it difficult to quantify". This was also evident in this study, with each stakeholder classifying their surplus material in different ways not necessarily following the definition of FAO. The findings from the interviews show how each stakeholder works individually, focusing on their own protocols to grow their business and remain viable. To ensure that the waste reduction targets of SDG 12.3 [4], of a 50% reduction by the year 2030, are successful, classifications or clear definitions of food loss and waste, surplus material and what is edible or not edible would need to be confirmed and communicated across stakeholders for improved uniformity.

3.3. Food Waste Reduction Targets

Most stakeholders ($n = 24$) in the survey disagreed that there were government incentives available to help manage food surplus, as can be seen in Figure 4. Some stakeholders acknowledged in-house incentives, although the response to this was mixed across all stakeholders, as seen in Figure 4.

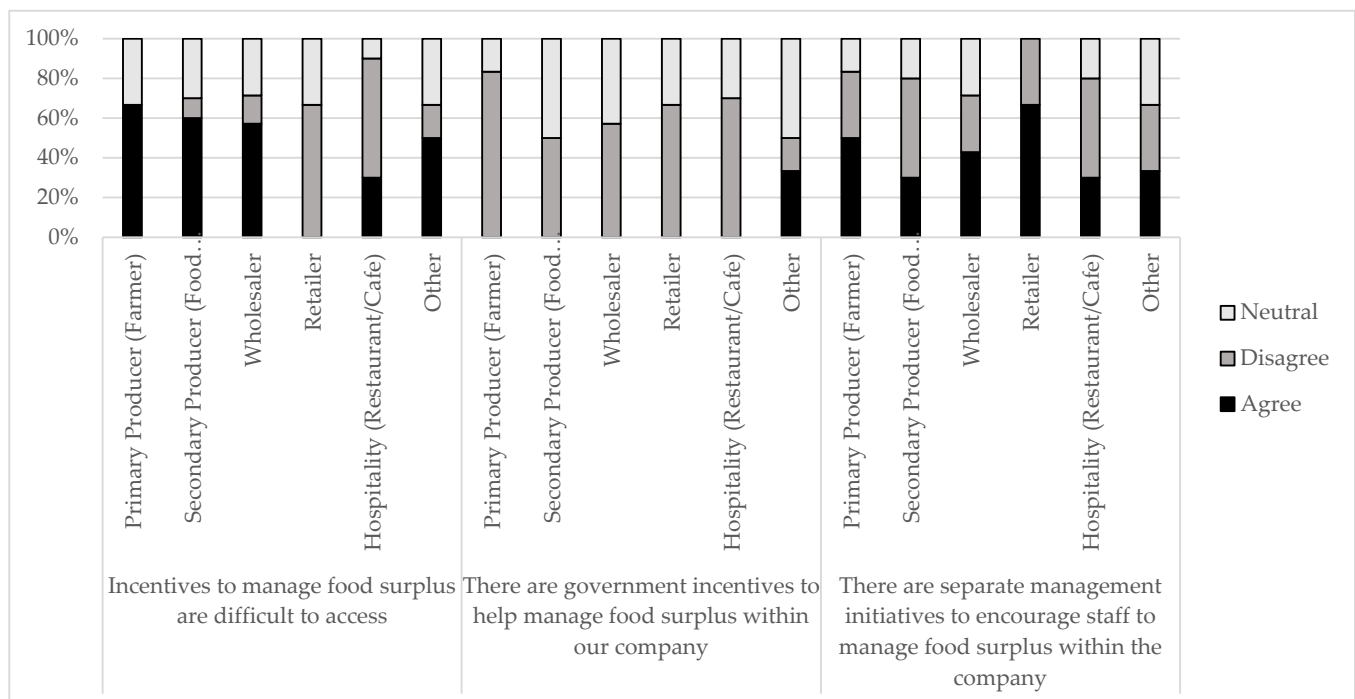


Figure 4. Survey responses to statements related to incentives for managing food surplus.

When food waste reduction targets were discussed during the interviews, most respondents noted that they were managing food waste in house anyway. Some were aware of initiatives, but most were not. The representative from retail believed the emphasis was wholly on food safety rather than food waste reduction.

However, they suggested the food waste reduction target of 50% by 2030, in line with SDG 12.3, was achievable, particularly if work has already commenced. They believed education was required to bring all stakeholders on board, consumers included, and alluded to the need for government policy to be implemented to fast track change.

3.4. Types of Surplus Material Available

The types of surplus material present varied between stakeholders, as can be seen in Figure 5. As seen in the figure, primary producers (farmers) responded that most of their surplus material comprised whole fruits and/or vegetables that do not meet retail/quality or food safety specifications. For secondary producers (food processors), it was peels, pips, cores, and other by-products generated by processing. These stakeholders also listed whole fruits or vegetables that do not meet specifications as the second highest response. Wholesalers were like primary producers in that out-of-specification whole produce was the highest response; however, they also logged products that had exceeded their expiration dates or produce that spoiled before its expiration date as other sources of surplus material. Retailers cited spoiled or contaminated products within their expiration dates as most of their surplus material. Respondents in the hospitality sector noted that their surplus material was mostly product remaining after processing, like peels, pips, and other by-products.

The reasons cited for the generation of this surplus material ranged from consumer expectations to short dates on deliveries and varied among stakeholders, as seen in Figure 6. Primary and secondary producers differed in that primary producers believed consumer expectations and retailer requirements mostly influenced the generation of surplus material. This was followed by overproduction due to forecasting or predicting orders. O'Connor et al. [14] agreed with this finding to some extent, suggesting that food waste was generated from produce that could not be sold, but also noted that pests and other production stresses also had an impact on food losses pre-harvest. However, for secondary producers,

surplus material was more influenced by quality and food safety specifications and raw material quality. Retailers were impacted across the spectrum, from raw material quality to forecasting to consumer expectations. Those in hospitality listed forecasting as the main contributor, followed closely by overproduction or production inefficiencies. For wholesalers, it was the raw material quality that impacted most, followed by forecasting. Other studies, like that from Beausang et al. [18], have expressed similar findings in relation to primary producers, highlighting the need for greater awareness of the impacts of retailer specifications that are directly linked to consumer expectations. This view was echoed in the interview findings, with the primary producers in this study finding alternative ways of using the produce that is not accepted by their customers, such as for fertilizing the land or feeding their animals. Research has also shown that waste materials from primary processing have further potential as new energy sources [51]. Like this study, studies from Richards et al. [52] and Messner et al. [10] focusing on Australian horticulture found that there were many "paradoxes" connected with the generation of food surplus in primary production, with a blame game happening in terms of who is responsible for the surplus, but ultimately feeling powerless to create change with the buyers, which are often the retailers in control. The stakeholders interviewed often referred to their immediate customers, the next stage in the supply chain, as impacting their business model. For example, the wholesalers and secondary producers were at the mercy of their buyers, namely the food service/food producer sectors or retailers who require a certain product specification. The retailers were then at the mercy of auditors measuring food safety protocols to keep consumers safe and, in turn, the impact of consumer expectations in terms of product quality and specifications.

The findings from the interviews highlighted customer- and product-related factors influencing the generation of surplus material. The sale of "ugly veg" was discussed by the stakeholders during the interviews, particularly the retailers, with a strong viewpoint that consumers will not buy imperfect produce, and as a result, imperfect produce is not being offered to them for sale. One of the farmers interviewed mentioned that the appearance of vegetables needed to be acceptable to the consumer, and in order to achieve this, farmers were removing outer leaves which would have been undesirable for the consumers although perfectly edible, but which were now being used as cattle feed. Teigiserova et al. [16] suggested that educating consumers about behavior and consumption habits linked to deformed or ugly vegetables might reduce food waste and losses attributed to this material. The EU commission is also reviewing the marketing of so called "ugly fruit or vegetables" by focusing on the freshness rather than the aesthetics, which should, in turn, reduce the amount of food waste [53].

Forecasting impacted fine dining restaurants and retailers specifically. These stakeholders were also impacted by logistics connected with deliveries either of raw materials or product coming or going via central distribution. Product promotions also had a negative impact on the generation of surplus material, resulting in single produce remaining unsold in favor of the multi-packs on promotion. Aschemann-Witzel et al. [54] also explained a further negative impact of supermarket promotions creating more food waste in households, as consumers take advantage of the cheaper pricing but may end up buying more produce than will be consumed. This may solve an issue at retail, but it is ultimately only passing the problem on to the next stakeholder, in this case the consumer. External factors such as the impact of weather or local calendar events like football matches or local weddings could impact sales and create surplus material. Labor was another factor indicated; those interviewed expressed an issue in retaining staff and maintaining a level of training which keeps surplus material managed effectively.

"Training as well, so we will leave the ordering up to our commis chef or sous chefs or chef de parti's and they might over-order" **Fine Dining Restaurant**

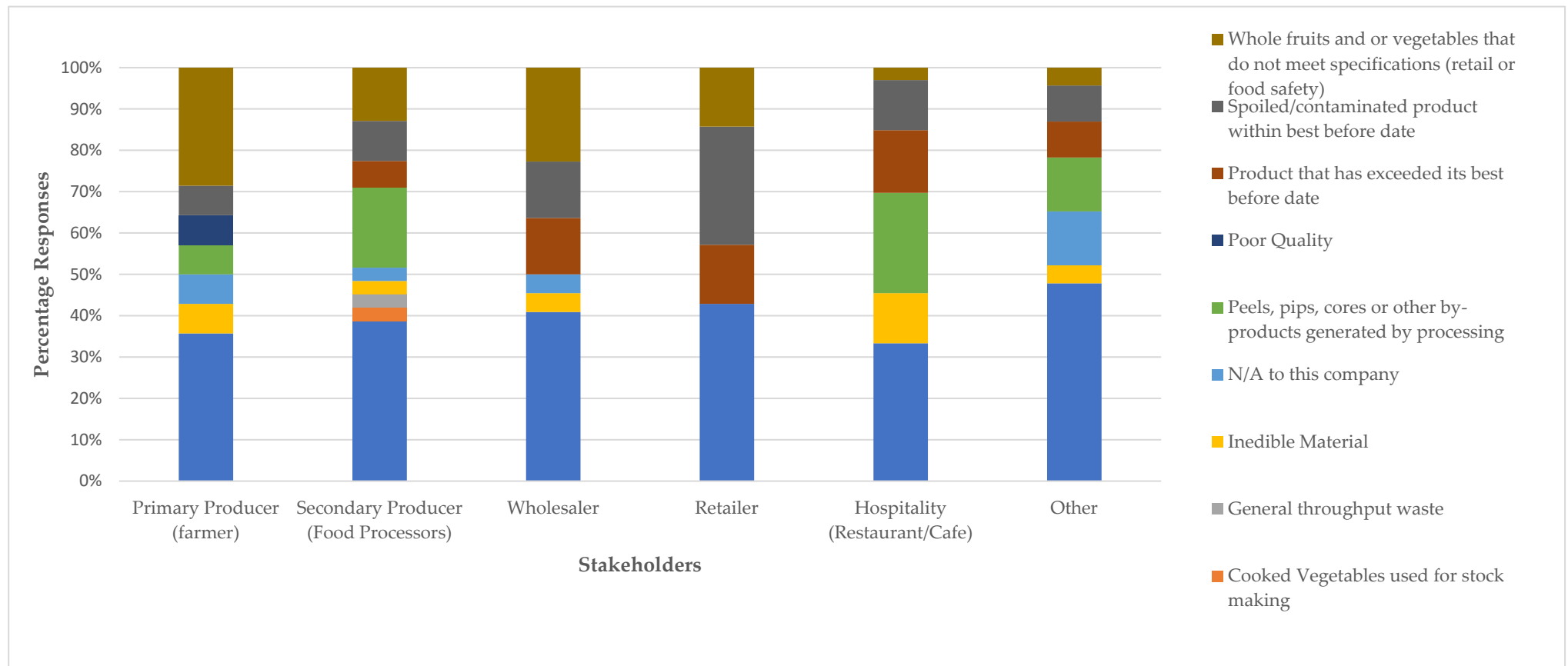


Figure 5. Types of surplus material present for each stakeholder sector (survey results).

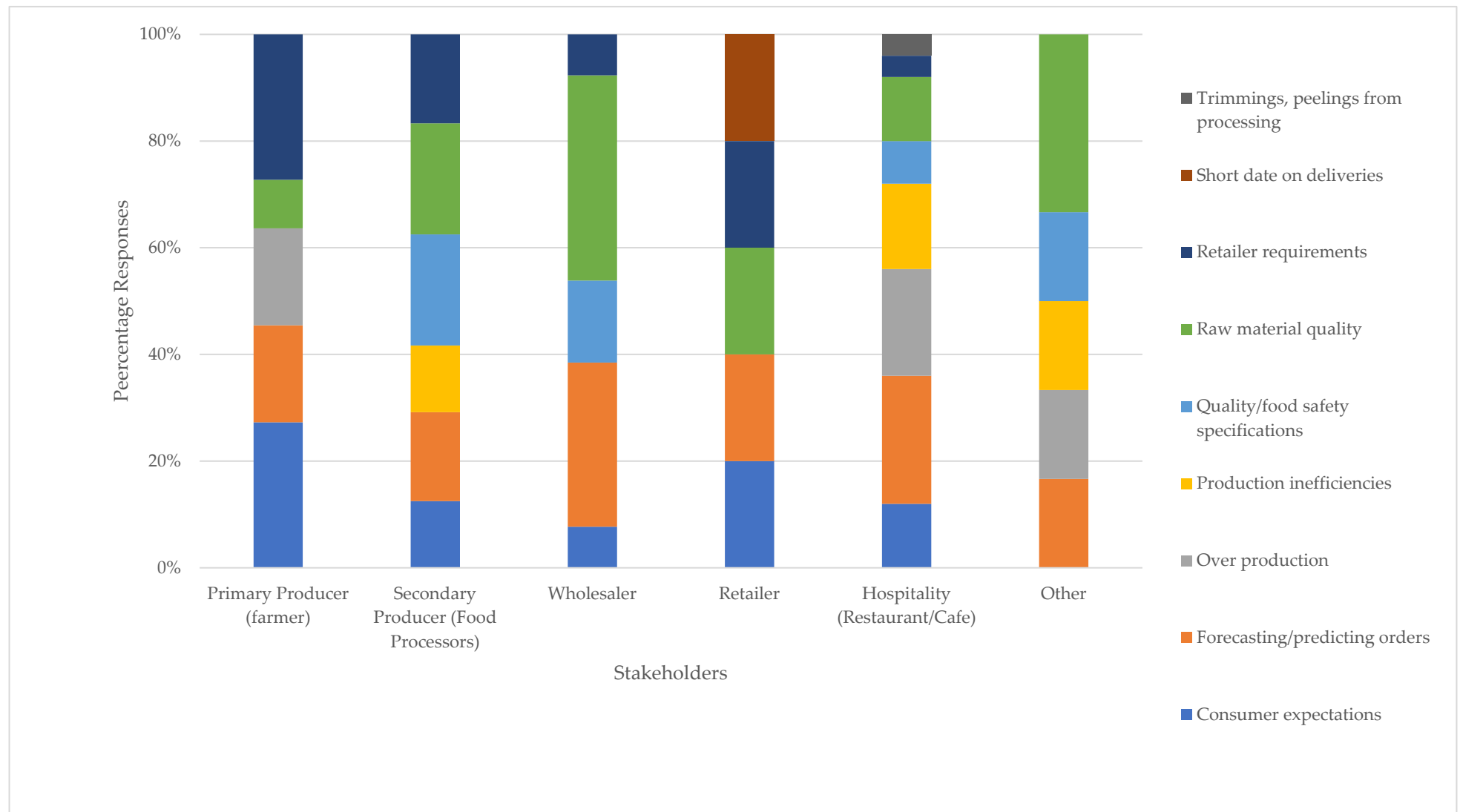


Figure 6. Reasons cited by the stakeholders in the survey for the generation of surplus fruit and vegetable material.

3.5. Valorization of Surplus Material

When investigating the barriers and drivers impacting stakeholder decisions to add value to surplus material generated (Q2), the participants were asked first, as described above, to state how they manage their surplus material. From the findings, only two respondents confirmed they are currently using surplus material in a side stream. However, almost half of the respondents (n = 21) indicated that they had identified potential side streams. The description of these side streams ranged from value-added food production (n = 7) to animal feed (n = 4), bioenergy production (n = 3), and redistribution for human consumption (n = 3). The stakeholders who had identified side streams were mostly primary or secondary producers as well as those in hospitality, but a small percentage of other stakeholders also identified side streams. Older studies stated that food producers have always considered using their by-products or side streams mostly to improve profitability [17]. What is interesting about the results in this study is the large gap between those already valorizing their surplus material and those who have not yet commenced this process. This may be due to the many barriers discussed below.

As mentioned previously, stakeholders often use this surplus material for animal feed, as it is a convenient source of feed for their own livestock. When the option to add value to this material was discussed with stakeholders in the interviews, the smaller businesses highlighted that "time" was a barrier, stating they did not have the necessary time or headspace to consider this option.

"We've discussed it from time to time, you know, the possibility of making broths, and stuff like that. But again, probably time, knowledge, expertise, has probably stalled us from going down that road" **Farmer/Wholesaler**

There is also the risk of a potentially negative economic impact that businesses need to consider. Valorization of this material should ensure a viable return on their investment, otherwise time spent focusing on other revenue streams would be more appropriate. Prior research on pilot scale valorization agrees with this finding, as there is a requirement for investment to ensure the safe extraction of surplus material for use in new waste-to-value production streams [19]. The findings from this study highlight the difficulties for the smaller stakeholders. Respondents recognized the potential benefits of valorization in theory, but to date, the focus has been on minimizing food waste. As a result, businesses may have to re-structure their operations to be able to valorize surplus material.

"What, we've gone on is minimization of the amount of waste. And then when we get to that point, we don't have the volumes" **Large Wholesaler**

This is in line with current recommendations, and as detailed in the food waste hierarchy, prevention is the most favorable outcome in terms of food waste management [9,18,55]. Those interviewed also preferred to donate produce to local restaurants and cafes if there were no other way of selling the produce, which is also a feature of the food waste hierarchy as a way of reducing food waste.

They also highlighted the need for external supports in terms of research and education, as well as financial support.

"I just don't have the facilities, like I know somebody who has facilities, and they have 0% waste in their fruit and veg. So, you know, if you had the capital investment" **Retailer**

Food safety legislation was believed to be restrictive, making the revalorization of food surplus, in some instances, prohibitive.

Previous review studies on food waste valorization across Europe and other jurisdictions have echoed similar barriers, particularly linked to the associated costs of starting a new valorization process, like new equipment and staffing, among other factors [19,35]. Garcia-Garcia et al. [36] also stated that it was necessary to identify a clear customer for these value-added products. However, when asked about how their customers would react to this kind of added-value product, the response was mostly positive, particularly if quality and cost factors were within customer expectations.

“There’s a certain element still, that look for service and all that but the bottom line is if the price isn’t lower than your competitor, they just won’t get it of you. It’s as simple as that” **Farmer/Wholesaler**

Ultimately, they believed it needs to make sense from a price perspective for the business model, as the quote above confirms, which is particularly relevant for the smaller businesses.

The results highlighted that transparency would be required to bring the consumer on board. McCarthy et al. [56] found that bringing positive and emotive messages linked to improving societal benefits by using surplus material that would have otherwise been wasted would improve the acceptance of these types of produce. This study also suggested that marketing and branding could be used to deliver the waste-to-value message in a user-friendly way to the consumer.

This study also recognized the importance of education in improving acceptance, with stakeholders educating their staff first, who in turn educate the customers on the lengths to which the businesses are going to reduce their food waste in creative ways. Aschemann-Witzel et al. [57] found increased acceptance of upcycled food products when frugality was highlighted. Some of the participants in this study recognized that they were missing an opportunity to demonstrate to their customers their own frugality and the sustainable practices currently in operation within their businesses.

“I suppose we should make more of a noise that the fact that it is organic, and we can, you know, therefore, we can use skins and things like that” **Cafe**

They also believed that introducing education to younger generations on where their food comes from would help to bridge the gap between industry and the consumer in terms of knowledge and ultimately acceptance of valorization of surplus material.

“I think if you showed people a basket of fruit and veg and say this is our fruit and veg, this is what you can do at home with your kids to educate them on this journey” **Retailer.**

This agrees with Rada et al. [58], who expressed the importance of educating young people on environmental issues, as this may help change behaviors within the family. It was also recognized that as the younger generation uses social media more often, this would be a good outlet to target food waste reduction campaigns [59]. Another study has shown that with more public discourse around food waste, waste-to-value products are better received by consumers, particularly if the sustainability impact of reducing food waste is expressed [39].

In terms of benefits of revalorization, they could see some potential long-term economic benefits after the initial investment period. Moreover, they recognized this as an opportunity to educate staff and customers on sustainability practices employed within their business models. It was viewed as a positive step for the company, providing the barriers alluded to above could be overcome.

3.6. Overview of Results

Although this was a small pilot study and not representative of all stakeholders, the results were in line with research findings to date, noting similar barriers to the revalorization of surplus material. Moreover, the explanatory mixed methods approach provided further validity to the findings, since the qualitative data generated from the interviews confirmed further and explained the results from the survey. The combined findings of this mixed methods study can be seen in Figure 7. These are presented under the five themes that emerged from the survey and the Interviews. The management of surplus material was viewed as important as an environmental metric by all stakeholders; however, the smaller stakeholders in this study did not have structured measurement protocols in place. The classification and the type of surplus material present are stakeholder-dependent, and most food waste reduction targets are driven by economic considerations. The findings also highlighted the lack of joined up thinking across the food supply chain on the topic of food waste management in general and the need for education and increased supports to create sustainable change in this sector.

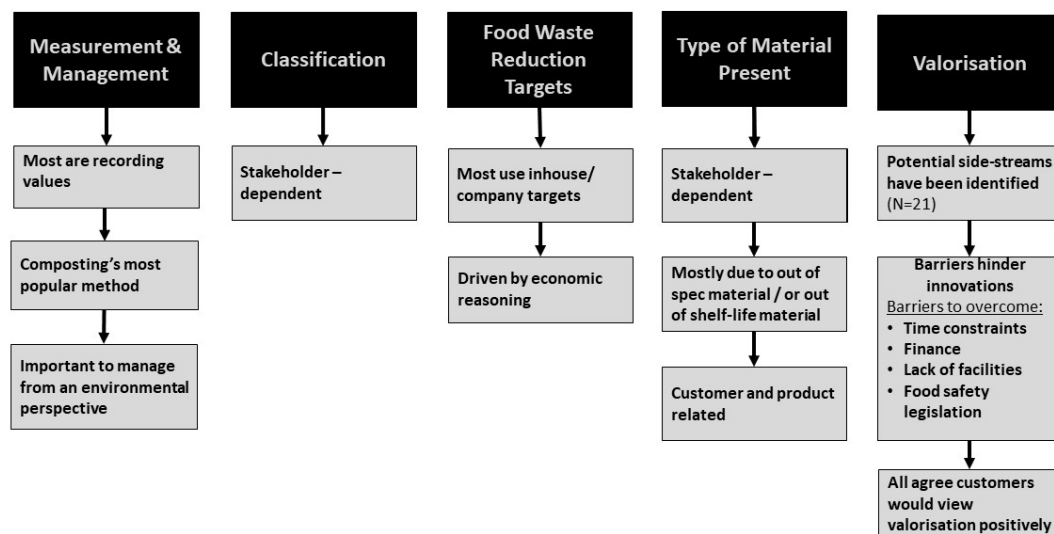


Figure 7. Summary of findings from stakeholders' survey and interviews, under the main headings investigated.

3.7. Limitations

One limitation of this pilot study was the relatively small sample size. In Ireland, several stakeholders would be classified as small or medium-sized businesses, and it proved difficult to access large numbers of these types of participants for the quantitative element of this mixed methods pilot study. Even large retailer brands are often franchised out to smaller operators. The voice of these participants was captured in the qualitative phase of this study, where a lack of resources was highlighted with the responses “*time poor*” and “*struggles maintaining a trained workforce*” mentioned frequently. However, for future studies, it would be recommended to find new avenues of recruitment to access larger numbers of these stakeholders.

4. Conclusions

This mixed methods pilot study focused on how stakeholders currently manage their fruit and vegetable surplus material, including by-products from their main production activity, and what factors impacted their decision to revalorize this material. The results confirmed that prevention is their primary motive in terms of management of their food surplus material. Trying to utilize all produce is mostly done for economic reasons. There is an interest in valorization; however, barriers such as time, lack of headspace to explore opportunities and a need for financial investment are preventing companies from taking this further, particularly small and medium-sized companies. The companies interviewed wear “*many hats*” in terms of their business models, with some being both primary and secondary producers as well as wholesalers. This means they are constantly evolving to remain profitable; therefore, policy changes or government support would be beneficial in assisting these types of companies in achieving sustainable changes.

Overall, there is a lack of joined-up thinking to bring resources together to create positive sustainable change, such as bio-refinery projects that smaller companies could feed into to help meet the food waste reduction goal of SDG 12.3. Each stakeholder interviewed showed they were doing their part to manage food waste; perhaps a new forum could be established to allow industry stakeholders to share ideas that have worked positively for them and could, in turn, help others to adapt their own practices. The disconnect between the consumer and the industry in terms of how consumer expectations impact the produce on the supermarket shelves is clear. An open, transparent dialogue between all stakeholders, including consumers, is critical if this narrative is to change. It was recognized that by sharing the current sustainability measures already in place through education with their own staff initially, followed with their customers, may start a positive chain of

discourse that ultimately reaches all parties, bringing the food waste dilemma into the public arena. Then, food waste revalorization could offer products acceptable to consumers, and in turn, a viable business model for stakeholders. Education could lead to consumer understanding of the benefits of revalorization, increasing further the acceptability of the products. Future studies could explore the connections between the food supply chain links to identify ways of improving waste reduction measures and encouraging revalorization through education and improved transparency.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su152316147/s1>, Table S1: Survey Question Grid; Table S2: Interview Question Grid; Table S3: Sample of Coding File (Thematic Analysis Phase 2—descriptive loose codes); Table S4: Sample of Coding (Thematic Analysis—Phase 3—developing categories/initial themes and Phase 4—developing potential themes).

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