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Discussing Food Waste Online: Current Trends in the Food Processing Industry and Future Directions

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Abstract: Food loss and waste is a recurring issue of discussion that food processing companies can no longer avoid. Society, stakeholders, and directives are demanding more and more communication on sustainability issues. However, only just under half of food processing companies stated that they provide consumer information on food waste. However, consumer information is only one way of communicating about food waste. The aim of this study is to identify key themes for relevant online communication on food waste that companies should be communicating to support the German National Strategy for the Reduction of Food Waste and to determine whether companies are already using these themes online. For this purpose, national strategy experts were asked through a questionnaire which topics were relevant according to the national strategy. The websites of 105 food processing companies were analyzed using content analysis to determine the status quo of food waste communication and assessed for relevance according to the national strategy. This paper presents five prioritized clusters of topics for relevant online communication on food waste for companies. The top priorities for communication, Cluster 1, are "Business Goals", "Business Strategy", "Process", "Consumer Information", "In-house Transparency", and "Utilization of Remaining Materials". The status quo shows that 43.8% of the companies provided online content regarding food waste. Through theory-driven content analysis, the three most common topics were identified in relation to food waste, namely the following: "Business Goals", "Product and Packaging", and "Consumer Information". Companies communicated in line with the priority clusters. However, the frequency of topics and the way they are communicated varies widely. Only "Consumer Information" and "Business Goals" from Cluster 1 are commonly communicated. During the COVID-19 pandemic and the war in Ukraine, there was a decline in publications on food waste, and afterward, more consumer-oriented content was published rather than communicating the relevant topics. Companies are expected to have two objectives in their communication: to communicate with consumers and to be transparent about their targets, data, and utilization of food waste. The results also show differences between subsectors, the occurrence of the topics over time, and examples. The findings are aimed at policymakers, researchers, and companies as a starting point for improving the consistency and transparency of food waste communication in line with the national strategy. The results are also of international interest due to the common challenges of food waste and international food companies.

Keywords: food loss; food waste communication; food industry; National Strategy for Food Waste Reduction

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1. Introduction

Food waste occurs along the whole food supply chain, from primary production to consumption [1]. Overall, 13.3% of the world's food is lost between post-harvest and processing [2], and 17% of available food is wasted on the way to or at the consumer level [2]. In Germany alone, approximately 12 million tons of food waste is generated across the whole supply chain every year [3]. Due to the enormous waste of resources, such as land, water, and energy, reducing food waste is an ethical, environmental, and economic challenge [4]. To address the reduction of food waste, Sustainable Development Goal (SDG) 12.3 aims to halve food waste at the retail and customer levels by 2030 and to reduce food waste along the entire supply chain [5]. This goal is also anchored nationally by Germany's National Food Waste Reduction Strategy [4]. To achieve the goal, this strategy places responsibility on all actors in the food supply chain, including food processing companies [4]. Partnership with the private sector is also important to the US and the EU [6,7].

Technical solutions for reducing food waste are already available, but the challenge lies in the sociotechnological domain [8]. Therefore, the German National Food Waste Reduction Strategy emphasizes that companies should raise awareness of the issue of food waste among other stakeholders, such as customers and employees, increase transparency along the food chain, increase collaboration efforts with and support of charitable organizations, and review the impact of marketing activities [4].

Communicating is one of the ways to get started. Even if each stage of the food supply chain is efficient in its own right [3], food companies have an essential role in preventing food waste at other stages of the supply chain, not just in reducing their own food waste but also in influencing other actors in the chain [9]. Their communication and collaboration with all stages along the supply chain is essential to reduce food waste [10]. Moreover, collaboration and communication are considered the overriding critical success factors to reduce food waste in the food supply chain [11,12]. Therefore, communication on food waste is not just about providing information to consumers. Richter and Bokelmann [10] point out that companies should strive to provide information about the company's activities and commitment in relation to food waste, as well as the importance of food waste and the process of food production in general. Communicating about food waste could set a company apart from its competition because food waste is generally not used in advertising [10]. Communicating about food waste can help improve the perception of products [13]. In fact, communication that considers environmental activities and food donations as issues can lead to competitive advantage through image improvement [10,14]. Companies also recognize that sustainability can improve their strategic position [15]. Furthermore, communication about food waste has been shown to have a positive impact on consumers in previous research [10,16]. It is expected that if companies report more on the issue of food waste, it will lead to increased awareness among participants throughout the whole value chain [10]. Communication can help to improve the consumers' food management skills [9,17]. In the same way, communication with consumers is important to gain knowledge about their behaviors in order to design products and improve processes [17,18].

In our previous studies, the issue of communication about food waste was a recurring theme. In the first study, companies were asked to identify good practices in food waste prevention [17]. The second study then asked companies to rate these measures and indicate the status of their implementation within the company [19]. The first study found that companies see communication with customers as a valuable way to reduce food waste. This was a different picture from other studies, which concluded that companies were not communicating with customers about food waste [10]. However, our second

study showed that, according to the companies' self-assessment, communication with customers about food waste is not used very often and is not considered effective [19]. The level of implementation of communication activities on food waste is 46% in the food industry, which was rated as partially implemented [19]. Richter and Bokelmann [10] point out that 65% of the companies reported that the topics of organic production and sustainability would be more suitable for consumer communication than the topic of food waste. Companies do not expect to gain a competitive advantage by minimizing food waste, although they closely monitor their competitors and react to their actions [10]. Nevertheless, some companies signaled that they would become more engaged if consumer interest increased on the topic [10]. This creates somewhat of a causal loop, but the demand for information is growing.

For years, media and political interest in the topic of food waste has been growing, whether through sustainability goals, coming directives for reporting [20], national strategies [4], agreements [21], or action weeks against food waste [22]. Information about food waste is no longer sought exclusively by consumers. It turns out that communicating about food waste can be a multifaceted endeavor, and many other stakeholders are now expressing their demands to companies. In the future, companies may have the intention or even the obligation to report as part of their processes, for example, through the European Union's Sustainability Reporting Directive (CSRD) [20]. This indicates that the European Union's Green Deal has motivated some companies to address food waste in their reporting [23].

However, it is unclear which priorities companies should set in their communications. Therefore, suitable communication in the context of this issue should be developed and promoted to companies early [10,19]. Numerous studies provide recommendations on how to effectively inform consumers about food waste [24–27], but none make recommendations about overall communication. Previous studies have focused on the impact of food waste messages on consumers [24,25], on food waste start-ups [28], on food communication of companies in the context of sustainability [29], and on the analysis of annual reports across the supply chain to identify food waste reduction measures as part of the From Farm to Fork strategy [23]. In addition to consumer information, transparency is a key requirement, as emphasized by the national strategy demands [4]. Leverenz et al. point out that there are still data gaps for the processing and manufacturing sectors that need to be improved [30]. The US and France also face the same challenges of data gaps in the processing sector [6,31]. It is unclear what information companies should communicate or share to support the national strategy.

Due to the different requirements for food waste communication, it is necessary to take a closer look at what food waste communication is needed to support the national strategy and how communication is implemented within companies. No research has yet been carried out on the online communication of food processing companies on food waste in the context of the national strategy. This study fills this gap by exploring what companies should prioritize when communicating about food waste to actively support the national strategy and whether food processing companies' food waste communication supports the national strategy. These results are not only important for the German national strategy [4]. They are also of European and international importance through the UN Sustainable Development Goal 12.3 [5] and the European Union's Sustainability Reporting Directive (CSRD) [20].

Aim of the Study

Considering the above, the aim of this study is to identify key themes for relevant online communication on food waste that companies should be communicating to support

the National Strategy for the Reduction of Food Waste and whether companies are already using these themes. It also aims to identify gaps and provide recommendations on how to start communicating about food waste. For this purpose, a questionnaire was sent to national strategy experts, and food company websites were analyzed using content analysis to determine the extent of food waste communication. The status quo of food waste communication was assessed for relevance according to the national strategy.

The research questions (RQs) of the study are the following:

- RQ (i): What themes should companies prioritize for communication in relation to the German National Strategy for the Reduction of Food Waste?
- RQ (ii): How many food processing companies communicate online about food waste?
- RQ (iii): What actions related to food waste are commonly communicated online in the food processing industry, and how do companies differ in their communication?
- RQ (iv): To what extent are companies implementing communication recommendations on food waste messaging to increase consumer awareness and intention to reduce food waste?
- RQ (v): Does self-assessment of the implementation and effectiveness of food waste measures play a role in the choice of topics communicated?
- RQ (vi): Do companies prioritize communication in relation to the German National Strategy for the Reduction of Food Waste, or is there a need for action?

This study is the first attempt to evaluate companies' online communication on food waste on their websites in relation to the national strategy. It offers a prioritized list of topics for food processing companies to address in support of national food waste targets. It also provides current corporate communications on food waste, the occurrence of the topics over time, and survey results to identify communication gaps and recurring themes. Food waste communication that is analyzed refers to all information about food waste, not just consumer information and tips. The study integrates data from our previous research [17]. This study presents three important contributions. Firstly, the study provides a framework for evaluating communication in line with the German National Food Waste Reduction Strategy. Secondly, the results show the current state, changes, and gaps in online communication on food waste. Finally, they are intended to serve as a starting point for decision-makers and food companies, providing guidelines, recommendations, and ideas for improving or initiating communication on food waste. As companies operate internationally and food waste is an international challenge, it is important to note that this work is not limited to Germany.

2. Materials and Methods

This study is a follow-up to two previous studies [17,19]. In this study, the status quo of food waste communication was assessed for relevance according to the national strategy. For this purpose, national strategy experts were asked to take part in a standardized questionnaire on the relevance and priority of food waste topics to identify priority clusters. Furthermore, the websites of 105 German food companies were analyzed using structured content analysis to determine what the companies communicate online about food waste. Finally, the data were compared and assessed. An attempt would also be made to justify the selection of topics by companies by linking to older data.

2.1. Questionnaire on the Relevance and Priority of Food Waste Topics

To address research question RQ (i), an online questionnaire was developed to evaluate the relevance and priority of various food waste topics in relation to the national strategy. The topics to be evaluated come from one of our previous studies, "Recommendation of good practice for preventing and handling food loss and waste in the food processing indus-

try" [17]. Through a survey of food industry experts and a comprehensive literature review, Rösler et al. [17] identified 53 different recommendations for preventing and managing food waste in the industry. These recommendations address both internal and external actions, from dealing with suppliers to communicating with customers. The recommendations are organized into four stages, nine areas, and 22 categories, systemically along the food supply chain, from suppliers (upstream supply chain), within the company, to customers (downstream supply chain) and beyond of the supply chain. Figure 1 provides an overview of the different areas and categories. For the questionnaire, 22 sub-areas were used.

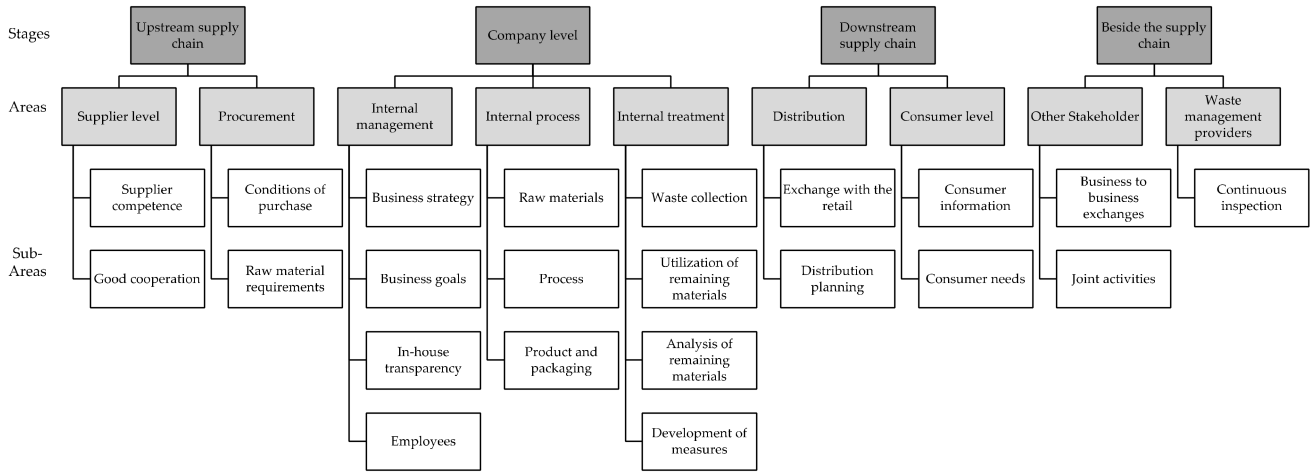

Figure 1. Overview of the categories and sub-categories according to Rösler et al. [17], which were used for the questionnaire and as a theory-based category system for the structured content analysis.

The questionnaire was divided into four sections:

1. General Information: This section gathered details about the organization, the perceived importance of the issue, and an assessment of the company's stance.
2. Topic Relevance: The second section listed 22 topics (as shown in Figure 1), supplemented with examples. Participants were asked to rate the relevance of each topic to the national strategy on a five-point scale, ranging from "very unimportant" to "very important".
3. Priority Ranking: In the third section, participants ranked the 22 topics based on their personal priorities, with 1 representing the highest priority and 22 the lowest.
4. Feedback and Suggestions: The final section invited participants to suggest additional topics and share feedback regarding company communication.

The online questionnaire was distributed via email in autumn 2024. The target audience included individuals involved in implementing the National Strategy for the Reduction of Food Waste. It was sent to all 16 ministries responsible for the environment, agriculture, and consumer protection across the German federal states, as well as to the 16 consumer advice centers in these states. Additionally, the Federal Ministry of Food and Agriculture (BMEL) received the questionnaire. The responsible contact person at BMEL subsequently distributed it to the target group using their internal email distribution list. The questionnaire was also sent to universities and research institutes working closely with the national strategy and internationally on food waste.

2.2. Data Analysis to Identify Priority Clusters

All responses were anonymized, and incomplete submissions were excluded. Microsoft Excel and SPSS (29.0.2.0) were used with univariate and bivariate analysis methods. First, the mean relevance score was calculated for each topic, and the topics were ranked from 1 to 22 based on their relevance. Second, the mean priority rankings were determined,

also ranging from 1 to 22. Third, the relevance and priority rankings were compared (see Section 3.1). Hierarchical cluster analysis in SPSS was used to form clusters [32], with the MoSCoW method serving as the basis for naming these clusters [33]. Finally, participants' suggestions and preferences were summarized.

2.3. Website Data Collection

In order to select a wide spectrum of companies, all companies from the list of the top 100 food retail suppliers in Germany [34], as well as all companies from the group of the Federation of German Food and Drink Industries [35], were selected. These lists were selected to target larger companies that have been in the market for a long time and are likely to have the time and resources to implement food waste measures. After removing 21 non-food companies and 24 duplicates, 105 companies were used for analysis. The non-food companies were easily identified by the "non-food" information in the list. For a more detailed description of the sample, information on the number of employees was collected from the Federal Statistical Office (Destatis) [36], company websites, and business journals such as Handelsblatt [37] and Lebensmittelzeitung [38].

The search was conducted through the websites of the 105 companies by using the following key phrases "food waste", "food loss", and "waste" in terms of raw materials and products to explicitly identify the food waste content without other waste content. The analysis was conducted in winter 2023/2024. The investigation of the websites followed the same pattern. For this purpose, Google's search operators [39] were used with the keywords in German and English. First, the following search algorithm was entered into the Google search mask: "site:www.website.com" "food waste" OR "food loss" OR "waste". Second, the Google description of the search results was checked for real references to food waste, specifically for the keyword 'waste'. The search results for 'waste', which were not further defined or did not refer to food, were not considered. Some search queries resulted in more than 10 pages of Google's result set. Thereby, only the first 10 pages of Google's result set for each website were considered, as the results were no longer associated with the company being searched for after the fifth page of the Google result set. Only about 10% of the companies surveyed displayed more than 10 pages of the Google result set. Third, the websites and documents were accessed and examined based on the key phrases to ensure that they were actual content and not just a link to another website. Finally, the findings were collected using the MAXQDA Website Collector for the subsequent content analysis [40]. For this purpose, the software saves the website in a usable offline format for the qualitative data analysis software MAXQDA 2022 (22.8.0). Duplicate search results were not considered. In total, 105 company websites were scanned using the described procedure. The identified webpages and PDF documents from the search formed the data corpus of the analysis.

2.4. Website Content Data Analysis

In order to answer the RQs, the results of the online research were analyzed and structured using deductive content analysis [41] and the qualitative data analysis software MAXQDA 2022 (22.8.0). The analysis consists of four steps. First, to answer RQ (ii), all documents and websites were individually described according to their data variables, such as document type, company, subsection, document context, references used, and year published (see Section 3.2).

Second, the paragraphs in all datasets that contained a reference to the key phrases. Further, the selected paragraphs were analyzed and structured to the appropriate categories of a theory-based category system using structured content analysis [41]. The selection of the theory-based categories, as well as the topics of the questionnaire, is based on the results

of our previous study (see Figure 1). In order to structure the references in the documents into the respective categories, the detailed descriptions of the categories from the previous study are used as anchor examples [17]. The predefined descriptions make distinctions between the 22 categories, such as "Buy raw materials in appropriate package sizes" for the category "Raw material requirements" or "Maintain direct contact with consumer to get feedback" for the category "Consumer Needs". Phrases were then assigned to the categories if they were a match for the anchor examples of the respective categories. Continuing in this manner, all the datasets and marked paragraphs were analyzed.

Third, to answer RQ (iii), univariate analyses were conducted to determine which actions against food waste were most communicated online based on the previous content analysis. The results were aggregated into the 22 categories (see Figure 1) without duplicating, meaning that each company was counted only once per category. The results were presented as relative frequencies. Subsequently, the results were then ranked to identify the most communicated actions (see Section 3.3). Fourth, the publications found are sorted by year to reveal possible changes in communication topics over time. For this purpose, a bivariate analysis was conducted to compare the topics with the year of publication. (Section 3.4). Finally, the extracted materials were paraphrased and summarized by categories and then by areas to provide an overview of the subject matter (see Section 3.5). To emphasize the communication aspect, the categories are now called topics in the results.

2.5. Detailed Analysis of Consumer Communications

To address research question RQ (iv), comprehensive literature research, summarizing content analysis, and deductive content analysis were conducted. First, comprehensive literature research was conducted to identify recommendations for food waste messages. The search was conducted through Science Direct and Research Gate by using the keywords "food waste message" and "food waste communication". Titles and abstracts were screened for references to food waste communication to select relevant documents. A total of 47 documents were identified. Next, the documents were screened for recommendations on food waste messaging to increase the awareness of consumers and their intention to reduce food waste. A total of six peer-reviewed articles were found that provided messaging recommendations to increase consumer awareness and intention. Second, the recommendations that were identified were paraphrased, reduced, and summarized according to the summarizing content analysis [41] to create a category system. The results build the category system for the deductive analysis that follows (see Section 3.6).

Third, the individual phrases from Section 2.4 were analyzed, which were assigned to the category "Consumer Information" (see Figure 1). For this purpose, the content of the "Consumer Information" category was structured according to the respective recommendations from the literature, again using deductive content analysis [41] and the qualitative data analysis software MAXQDA 2022 (22.8.0). Finally, a univariate analysis was conducted to determine the frequency of implementation of food waste messages recommended in the literature in the context of online consumer communication about food waste per company (see Section 3.6).

2.6. Data Assessment

To address research question RQ (v), bivariate analysis was conducted to compare the frequency of communicated actions against food waste with the status quo of implementation, as well as their effectiveness and feasibility in the industry (see Section 3.7.1). The data for the comparison, the status quo of the implementation, the effectiveness, and the feasibility are taken from a previous study [19], which is publicly available.

Finally, to answer research question RQ (vi), a further bivariate analysis was conducted to compare the identified priority clusters, and the results were compared with those of the status quo analysis (see Section 3.7.2).

3. Results

This chapter presents the results of the questionnaire (Section 3.1), the sample of the website analysis (Section 3.2), the status quo of the food waste communication (Section 3.3), temporal changes in communication strategies (Section 3.4), the frequently communicated content on food waste (Section 3.5), a detailed view of consumer communications (Section 3.6), and the comparison of the status quo with companies' self-assessments and questionnaire results (Section 3.7). In addition, different subsectors of the companies were compared with each other, and the occurrence of the topics was examined over time (Sections 3.2 and 3.3).

3.1. Priority Clusters of Relevance to the National Strategy

This section presents the responses to the questionnaire and the answers to RQ (i) on which themes companies should prioritize for communication in relation to the German National Strategy for the Reduction of Food Waste. For this purpose, a survey was conducted among experts working in the field of the National Strategy for the Reduction of Food Waste. The questionnaire was answered by 19 participants. Twelve of the participants came from the political sphere: eleven of them were from ministries, and one was from another authority. Three other participants come from consumer advice centers, and four participants from the research sector. On a five-point Likert scale from very important to very unimportant, they considered corporate communications on food waste to be important. The first step was to average the responses from the questionnaires, as well as the strategic relevance and prioritization. Hence, all values are averages. The data were compared in a scatter diagram to form priority clusters (see Figure 2). On the *x*-axis, the ranking of the priorities for the implementation ranges from 22 out of 22 (lowest rating) to 1 out of 22 (highest rating). On the *y*-axis, the ranking of relevance for the National Strategy against Food Waste is from 22 out of 22 (lowest rating) to 1 out of 22 (highest rating). Second, a hierarchical cluster analysis was performed on the data using SPSS [32]. The classification of the hierarchical analysis was used to color the individual topics within a cluster in the diagram (see Figure 2). Further, the clusters were named in a modified way based on the MoSCoW method [33]: must = highest priority to nice = lowest priority. Therefore, the cluster with high relevance and high priority was placed at the highest level, followed by the cluster with high relevance and medium priority, then medium relevance and high priority, and finally, the cluster with no relevance or priority.

The relevance rating compared (*x*-axis) with the priority level (*y*-axis) shows a clear distribution of the rankings, which made it possible to cluster the topics and divide them into five clusters. Most topics are grouped in the blue clusters (8 topics). The blue cluster combines topics that have low priority and low relevance. Due to their low importance, the blue clusters can be described as "nice-to-have" with Priority 5 for implementation. The red cluster is the opposite of the blue cluster. The red cluster lists topics that are considered high priority and high relevance and can be described as "must-have" with Priority 1 for implementation. These include the topics "Business Goals" (1;1), "Business Strategy" (2;7), "Process" (4;8), "Consumer Information" (5;2), "In-house Transparency" (6;5), and "Utilization of Remaining Materials" (10;5). The other three clusters are the green, purple, and yellow clusters. The green cluster contains hthe igh relevance and medium priority topics "Joint Activities" (13;2) and "Conditions of Purchase" (17;2). Due to the high relevance of the cluster but medium priority, it can be described as a "need-to-have"

with an implementation priority of 2. The purple cluster is of medium relevance but high priority. Due to the high priority of the cluster, it can be described as a "should-have" with an implementation priority of 3. This cluster contains "Distribution Planning" (8;10), "Good Cooperation" (9;11), "Analysis of Remaining Materials" (11;14), "Raw Material Requirements" (14;12), "Product and Packaging" (15;8), and "Consumer Needs" (16;12). The last cluster, the yellow cluster, is of low relevance and medium priority. It contains the "good-to-have" topics "Development of Measures" (3;15), "Raw Materials" (7;18), and "Employees" (12;20). The clusters show how companies can support the national strategy through their choice of topics. Companies should prioritize topics from the red cluster rather than developing topics from the blue cluster.

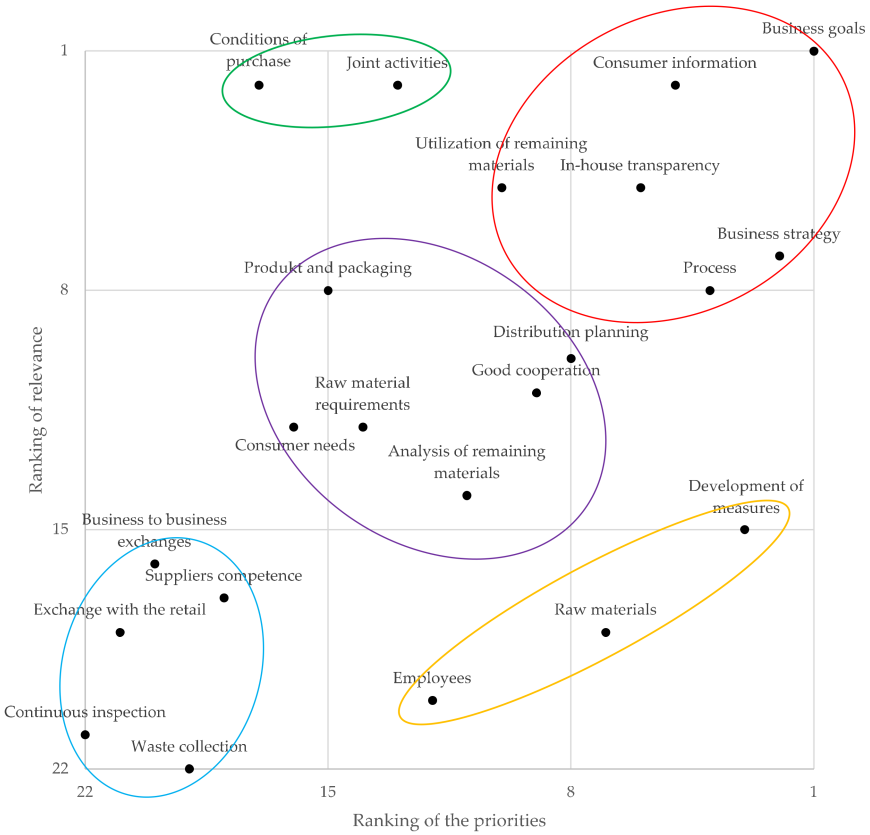

Figure 2. Priority clusters of topics to be communicated according to the National Strategy for the Reduction of Food Waste. The relevance rating is compared with the priority level data from the expert survey. The scale ranges from 22 out of 22 (lowest rating) to 1 out of 22 (highest rating). Divided into five clusters: red = must-have (Priority 1), green = need-to-have (Priority 2), purple = should-have (Priority 3), yellow = good-to-have (Priority 4), and blue = nice-to-have (Priority 5) (n = 19).

In addition to rating the topics, respondents also indicated which topics were missing in companies and what they would like to see in corporate communications in general. Companies should distinguish in their reporting between edible and non-edible food waste and between avoidable and unavoidable food waste. They should analyze what has been done, which actions really make a difference, and how much food was saved or reused. Companies should self-report food waste and focus on reducing packaging. They should not just state their strategy but also communicate its implementation and the extent to which they have achieved their goals. Moreover, companies should back up their statements with real figures in order to increase transparency for consumers and should communicate more about the German Food Waste Pact [42]. Companies should provide open and honest documentation of the actual situation, reduction targets, binding data reporting

for companies, presentation of specific avoidance strategies and innovative solutions, and detailed root cause analysis. The results should be compared with previous results and statements, and it should be explained why higher reductions could not be achieved. This would make it possible to publish interim results during the year and to assess the influence of seasons, vacations, and holidays. Moreover, penalties for misreporting should be in place to prevent greenwashing. There is also a need to assess the social and economic impact of waste in companies. Finally, companies should be transparent about the use of volumes for donations, factory sales, or other side streams.

3.2. Description of Website Analysis Samples and Data Materials

This section answered RQ (i). Table 1 shows the selected companies and the companies with search hits that provided information on food waste. In total, 46 of 105 companies (43.8%) had information regarding food waste on their websites. Nearly every subsector reported something about food waste. The convenience food (n = 9; 19.6%) and the dairy sectors (n = 9; 19.6%) had the most companies providing information on food waste in this analysis. A total of 59 of the companies analyzed (56.2%) had no information regarding food waste on their websites. A total of 71.4% of the sample consists of large companies with more than 1000 employees. In the two categories "more than 1000" and "501–1000 employees", information on food waste is only found in half of the companies.

Table 1. Description of the total samples selected for website data collection by subsector and number of employees, as well as results of samples with and without search hits.

Subsectors	**Selected**		**With Search Hits**		**No Hits**	
	Total (n = 105)	**%**	**Total (n = 46)**	**%**	**Total (n = 59)**	**%**
Meat products and sausage	18	17.1	6	13.0	12	20.3
Beverages	18	17.1	5	10.9	13	22
Dairy products and eggs	17	16.2	9	19.6	8	13.6
Sugar and confectionery	16	15.2	6	13.0	10	16.9
Convenience food	15	14.3	9	19.6	6	10.2
Bakery and farinaceous	11	10.5	6	13.0	5	8.5
Spices, tea and coffee	7	6.7	4	8.7	3	5.1
Fruits and vegetables	2	1.9	0	0	2	3.4
Fish and seafood products	1	1.0	1	2.2	0	0
Employees						
More than 1000	75	71.4	37	80.4	38	64.4
501–1000	16	13.3	7	15.2	9	15.3
Less than 500	14	15.3	2	4.4	12	22.3

In total, the search returned 216 hits. Each company had an average of 2.5 documents on the topic of food waste. The actual range was between 1 and 20 documents. Table 2 shows that 71.3% of all documents (n = 154) come from the convenience food sector (n = 73; 33.8%), the dairy sector (n = 51; 23.6%), and the meat sector (n = 30; 13.9%). The 216 documents from the data collection are 144 webpages (66.7%) and 72 PDF documents (33.3%). The topic of food waste was found in 20 different document contexts. In detail, the documents related to press and news (n = 55; 25.5%), sustainability reports (n = 37; 17.1%), blogs (n = 32; 14.8%), or webpages about sustainability (n = 29; 13.4%). A publication year between 2014 and 2016 was found for 7.3% (n = 16) of the documents, between 2017 and 2019 for 17.8% (n = 39), between 2020 and 2022 for 36.6% (n = 79) and for 2023 for 18.5% (n = 40). 19.9% of the documents (n = 43) could not be assigned a year.

Table 2. Data description of analyzed documents for website content data analysis by subsector, media type, context, and publication year.

Data Characteristics	Data Details	Total	%
Documents by sector (n = 216)	Convenience food	73	33.8
	Dairy products	51	23.6
	Meat products and sausage	30	13.9
	Sugar and confectionery	23	10.6
	Bakery and farinaceous products	18	8.3
	Beverages	12	5.6
	Spices, tea and coffee	5	2.3
	Fish and seafood products	4	1.9
Type of media (n = 216)	Webpage	144	66.7
	PDF document	72	33.3
Document context (n = 216)	Webpage—press and news	55	25.5
	PDF—sustainability report	37	17.1
	Webpage—blog and portal	32	14.8
	Webpage—sustainability	29	13.4
	Webpage—about us	10	4.6
	PDF—press release	8	3.7
	PDF—magazine	5	2.3
	PDF—newsletter	5	2.3
	PDF—policy report	5	2.3
	Webpage—process	5	2.3
	Webpage—responsibility	5	2.3
	PDF—consumer materials	4	1.9
	Webpage—brand	4	1.9
	PDF—annual report	3	1.4
	PDF—scorecard	3	1.4
	Webpage—reporting	2	0.9
	PDF—food waste report	1	0.5
	PDF—research report	1	0.5
	Webpage—FAQs	1	0.5
	Webpage—innovations	1	0.5
Year of publication (n = 216)	2014–2016	16	7.3
	2017–2019	39	17.8
	2020–2022	79	36.6
	2023	40	18.5
	No year	43	19.9

Companies used different sources to describe the importance of food waste. Table 3 provides an overview of the most common references used by companies for food waste information. In some cases, no explicit sources were given, only the name of the organization or government agency was given, or a hyperlink to the website was provided without describing exactly where the data came from. Some links were already broken. A total of 36 sources were identified and grouped into four categories: Government, Organizations, Studies and Reports, and Press and Media. The most frequently used references are the website of the organization TooGoodToGo (n = 11), the SDG 12.3 of the UN (n = 10), the Champions 12.3 of the World Resources Institute [43] (n = 9), the Farm to Fork Strategy from the European Commission [7] (n = 4), and the Baseline 2015 of the Thünen Institute [3] (n = 4).

Table 3. Overview of the most common references on the sites of the companies studied, sorted according to subject.

Category	References (n = 36)		Total (n = 90)
Government	United Nations	[44]	10
	European Commission (EC)	[7]	4
	Federal Ministry of Food and Agriculture (BMEL)	-	3
	World Food Programme (WFP)	[45]	3
	Food and Agriculture Organization (FAO)	[46]	3
	UN Environment Programme (UNEP)	-	2
	European Parliament	[47]	2
	Eurostat (EC)	[48]	1
	United States Department of Agriculture (USDA)	[49]	1
Organizations	TooGoodToGo	-	11
	World Resources Institute	[43]	9
	United Against Waste	[50]	4
	Waste and Resources Action Programme (WRAP)	[51]	2
	ReFED inc.	-	2
	Action Against Hunger	[52]	1
	World Economic Forum	[53]	1
	German Institute for Frozen Foods (DTI)	[54]	1
	Tafel (Food Bank)	[55]	1
Studies and Reports	Schmidt et al. (2019)	[3]	4
	UNEP (2021)	[2]	3
	EAT-Lancet-Commission (2019)	[56]	2
	FAO and WHO (2019)	[45]	2
	Gonzalez Fischer and Garnett (2016)	[57]	2
	FAO (2013)	[58]	2
	FAO (2009)	[59]	1
	European Union (2016)	[60]	1
	Luck und Obersteiner (2020)	[49]	1
	Waskow and Blumenthal (2016)	[61]	1
	Crippa et al. (2021)	[48]	1
Press and Media	Our World in Data	[62,63]	2
	The World Counts	-	2
	National Geographic	[64]	1
	Boston Consulting Group	[65]	1
	Reuters	[66]	1
	Handelsblatt	-	1
	Scientific American	[67]	1

- = broken link or general link to the home page.

3.3. Status Quo of Communicated Actions Against Food Waste

This section answered RQ (ii), "what actions related to food waste are commonly communicated online in the food processing industry, and how do companies differ in their communication?". The analysis shows that, overall, companies are communicating information that affects their entire food value chain. However, it shows that different companies set different priorities in their communication, so not all topics were covered by each company. Some topics were communicated by more than half of the companies, and some topics were to be found at very few companies or not at all. On average, companies report on five topics. The actual range is from one topic to 18 out of 22 topics, with a median of 3.5.

Figure 3 shows the status quo of the communication of actions against food waste along the food value chain. The diagram begins on the left with suppliers and ends on the

right with distribution, customers, and other stakeholders. The results were summarized and presented in the form of categories and areas (see Figure 1), where companies were counted only once per category and per area. The value of an area may be greater than the value of a single category because an area contains multiple categories and, therefore, multiple individual companies.

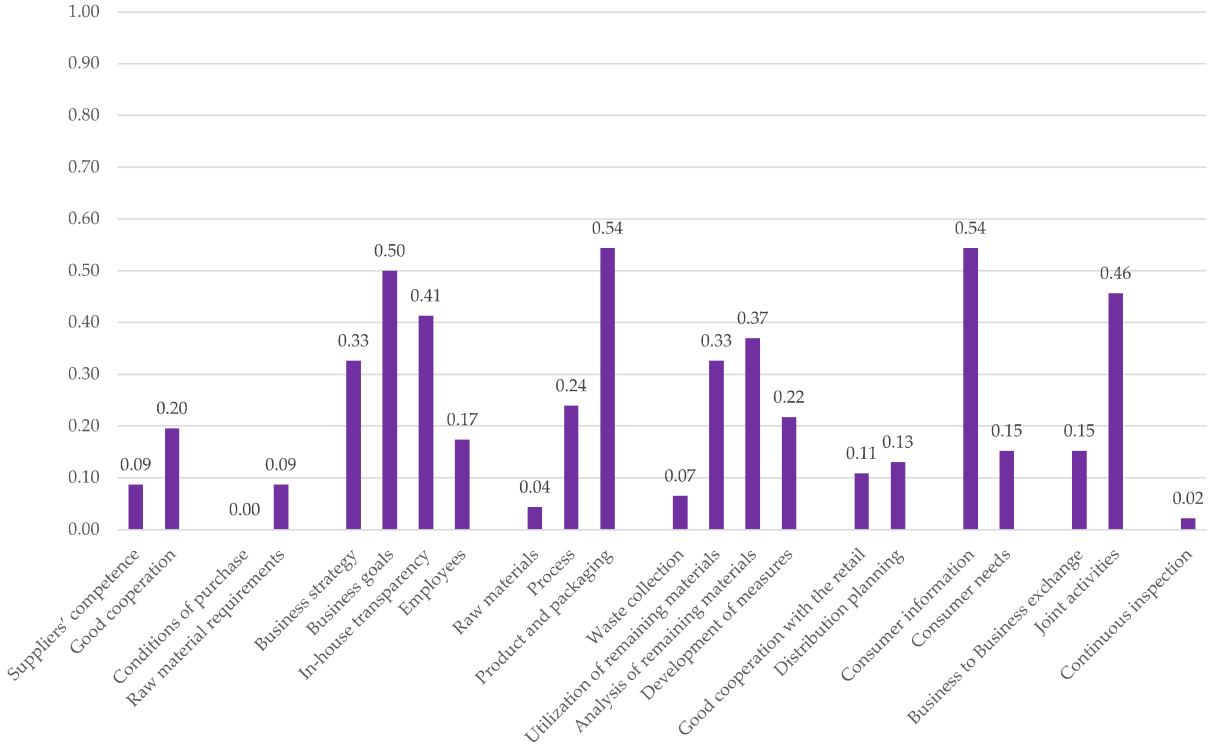

Figure 3. Status quo of the communication level of actions against food waste from food processing companies shown by the categories according to Rösler et al. [17]. Communication levels range between 0 (not found) and 1 (100% of companies analyzed) (n = 46). From suppliers to customers and beyond, the topics are organized from left to right.

In 3 out of 22 categories, the communication level was 50% or more, meaning that 50% or more companies communicated content on that topic. The most frequently communicated content related to the topics of "Product and Packaging" (54%) and "Customer Information" (54%), followed by "Business Goals" (50%). Almost half of all companies reported "Joint Activities" (46%). All other topics were addressed by far less than half of the communicating companies. The least communicated topics, that were communicated by less than 10% of the companies, are "Waste Collection" (7%), "Raw Materials" (4%), "Continuous Inspection" (2%), and "Conditions of Purchase" (0%).

In the same way that not every topic was addressed by all the companies, the topics were also addressed in different ways by the respective subsectors. Table 4 shows the status quo of the communication level in relation to the subsectors. Due to the large number of subsectors, the five subsectors with the highest number of companies were considered—convenience food, dairy, bakery, meat, and sugar. The results show that none of the topics can be clearly assigned to a single subsector or would be characteristic of that subsector; each topic was addressed by at least three subsectors, except for the topics that were generally not communicated much, such as "Conditions of Purchase", "Waste Collection", and "Continuous Inspection".

Table 4. List of food waste topics and their communication in percentages and ranking in the food industry by total and subsectors.

Categories	Total (n = 46)		Convenience Food (n = 9)		Dairy Products and Eggs (n = 9)		Bakery and Farinaceous Products (n = 6)		Meat Products and Sausage (n = 6)		Sugar and Confectionery (n = 6)	
	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank	%	Rank
Suppliers' competence	0.09	(17)	0.22	(13)	0.11	(14)	0.00	-	0.17	(16)	0.00	-
Good cooperation	0.20	(11)	0.22	(13)	0.22	(9)	0.00	-	0.33	(11)	0.33	(7)
Conditions of purchase	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-	0.00	-
Raw material requirements	0.09	(17)	0.11	(16)	0.00	-	0.00	-	0.33	(11)	0.17	(10)
Business strategy	0.33	(7)	0.56	(3)	0.33	(7)	0.17	(6)	0.83	(1)	0.17	(10)
Business goals	0.50	(3)	0.78	(1)	0.56	(5)	0.17	(6)	0.83	(1)	0.67	(1)
In-house transparency	0.41	(5)	0.56	(3)	0.67	(1)	0.00	-	0.67	(4)	0.50	(2)
Employees	0.17	(12)	0.33	(11)	0.00	-	0.17	(6)	0.50	(7)	0.17	(10)
Raw materials	0.04	(20)	0.11	(16)	0.00	-	0.00	-	0.00	-	0.00	-
Process	0.24	(9)	0.44	(6)	0.22	(9)	0.17	(6)	0.50	(7)	0.17	(10)
Product and packaging	0.54	(1)	0.44	(6)	0.67	(1)	0.33	(2)	0.83	(1)	0.50	(2)
Waste collection	0.07	(19)	0.00	-	0.11	(14)	0.00	-	0.17	(16)	0.00	-
Utilization of remaining materials	0.33	(7)	0.56	(3)	0.11	(14)	0.33	(2)	0.67	(4)	0.33	(7)
Analysis of remaining materials	0.37	(6)	0.44	(6)	0.56	(5)	0.00	-	0.67	(4)	0.50	(2)
Development of measures	0.22	(10)	0.33	(11)	0.33	(7)	0.00	-	0.33	(11)	0.33	(7)
Good cooperation with the retail	0.11	(16)	0.11	(16)	0.22	(9)	0.33	(2)	0.00	-	0.00	-
Distribution planning	0.13	(15)	0.11	(16)	0.22	(9)	0.00	-	0.33	(11)	0.17	(10)
Consumer information	0.54	(1)	0.78	(1)	0.67	(1)	0.50	(1)	0.50	(7)	0.50	(2)
Consumer needs	0.15	(13)	0.22	(13)	0.22	(9)	0.00	-	0.33	(11)	0.17	(10)
Business-to-business exchange	0.15	(13)	0.44	(6)	0.11	(14)	0.00	-	0.17	(16)	0.00	-
Joint activities	0.46	(4)	0.44	(6)	0.67	(1)	0.33	(2)	0.50	(7)	0.50	(2)
Continuous inspection	0.02	(21)	0.00	-	0.00	-	0.00	-	0.17	(16)	0.00	-

The average number of topics communicated by 50% or more of the companies is 3. The meat subsector communicates the most, with a total of 10 topics at or above 50%. The dairy and confectionery sectors each communicate 6 topics over 50% and the convenience food with 5 topics. The bakery subsector is the least communicative, with only one topic, "Consumer information" (50%). Furthermore, 13 topics were not addressed at all by the bakery subsector, while only 3 topics were not addressed by the meat subsector. However, "Consumer information" is the only topic addressed by more than 50% of all subsectors.

To facilitate comparison across subsectors, Figure 4 shows deviations of the subsectors from the mean value of the status quo of the communication in percent. As in the previous

table, only the subsectors with the highest number of companies and the greatest deviation from the mean value were included in the figure-convenience food, dairy, bakery, and meat. Although the sugar and confectionery subsector also has a higher number of companies, this subsector has been removed from the figure for the reasons of clarity and because there were no notable deviations from the mean. For a better overview, only the deviations above 5% are labeled in the figure.

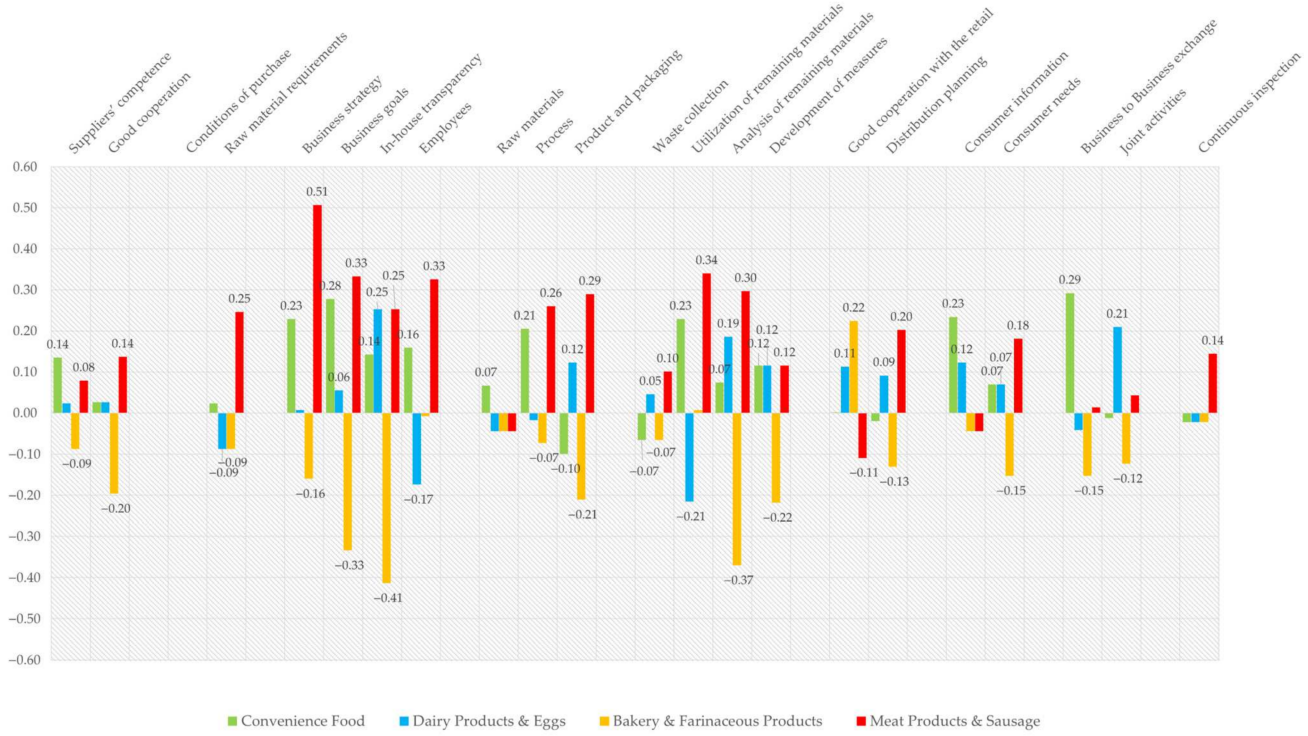

Figure 4. Deviations of the categories in percent from status quo of communication by subsector, convenience food (n = 9), dairy products (n = 9), bakery (n = 6), and meat products (n = 6). Note: positive = higher communication level than average, and negative = lower communication level than average. From suppliers to customers and beyond, the topics are organized from left to right.

The largest subsectors represented are dairy and convenience food. These two subsectors show individual deviations from the average communication level. Convenience food shows a higher level of communication than the average across almost all topics. In particular, the area of "Internal Management" was addressed more frequently, with the topics of "Business Strategy" (+23%), "Business Goals" (+28%), "In-house Transparency" (+14%), and "Employees" (+16%). "Process" (+21%), "Utilization of Remaining Materials" (+23%), "Consumer Information" (+23%), and "Business-to-business Exchange" (+29%) also deviated positively from the mean. Convenience food is the subsector that reports the most on the last two topics. The subsector communicates less than average regarding "Product and Packaging" (−10%) and "Waste Collection" (−7%).

In the dairy subsector, there is a wider spread between the different topics. This subsector also includes topics along the entire value chain that are addressed to an above-average extent, such as "In-house Transparency" (+25%), "Product and Packaging" (+12%), "Analysis of Remaining Materials" (+19%), or "Joint Activities" (+21%). Compared to the other subsectors, the topic of joint activities was discussed most frequently in the dairy subsector. At the same time, topics such as "Raw Material Requirements" (−9%), "Employees" (−17%), and "Utilization of Remaining Materials" (−21%) were discussed below average.

The bakery subsector shows negative deviations from the average in almost all topics. The only topic in which the subsector is more communicative than the average and all other subsectors is the topic "Good Cooperation with the Retail Trade" (+22%).

In contrast to the bakery subsector, the meat subsector is more communicative toward the average. The meat subsector is also the subsector that communicates each topic more frequently than the average and all other subsectors. The most frequently addressed topics in the meat subsector include "Business Strategy" (+51%), "Employees" (+33%), and "Utilization of Remaining Materials" (+34%). Only the topics of "Raw Materials" (−4%), "Good Cooperation with the Retail" (−12%), and "Consumer Information" (−4%) are communicated at a below-average level.

3.4. Temporal Changes in Communication Strategies

This section examines the trends observed over the study period. It analyzes two key aspects: first, the year-to-year changes in the number of publications and publishers; second, the evolution of individual topics to identify whether and how they developed over time.

Figure 5 provides a detailed overview of the distribution of documents published between 2014 and 2023 (red line) and the associated companies responsible for these publications (green line). Additionally, it highlights the number of companies that addressed food waste for the first time in each year (blue bars). The data from Section 3.2 were categorized chronologically for this analysis.

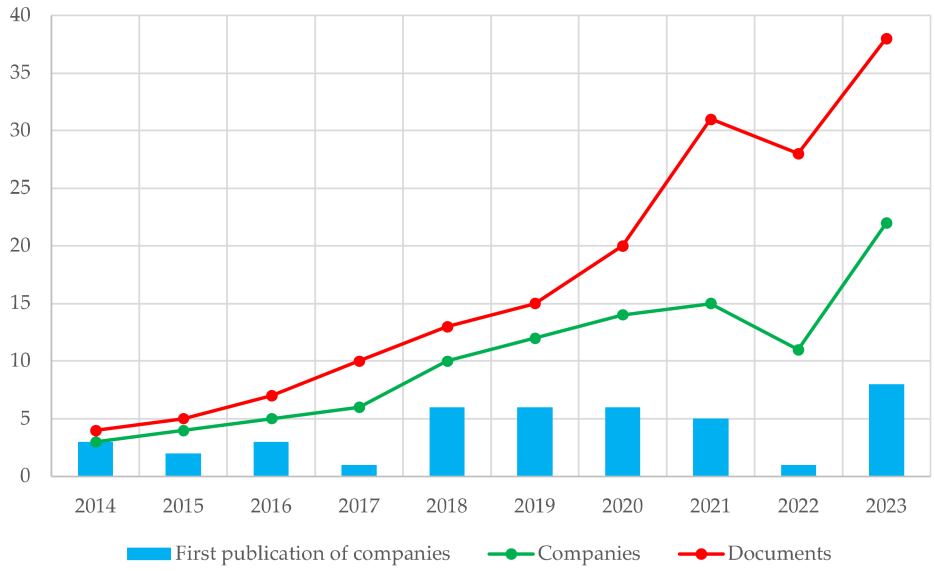

Figure 5. Overview of temporal changes, including the number of documents published per year (red, n = 216), the number of companies actively communicating per year (green, n = 46), and the number of first-time publications per year (blue). Note: Data lacking a specific publication year are excluded from this figure.

The number of publications steadily increased each year, peaking in 2023, the final year of data collection. However, a notable decline occurred in 2022, where both publication numbers and the number of active companies dropped significantly before recovering in 2023. A similar trend is evident in the number of publishing companies, which follows a comparable trajectory but diverges noticeably starting in 2020. This gap widens further in 2021 and remains consistent through 2023.

In terms of first-time publishers, the lowest numbers were recorded in 2017 and 2022. However, these years were followed by surges in new entrants, with 2023 marking the highest number of first-time publishers. A notable increase in new publishers was

also observed during the period from 2018 to 2020, demonstrating an overall growth in engagement with food waste topics.

Figure 6 illustrates the number of publications for the top three topics alongside four other topics with the greatest variation, categorized by year of publication. Data without a specified year were excluded for clarity. To maintain readability, the analysis focuses on these seven topics, as many other topics show little to no notable progression.

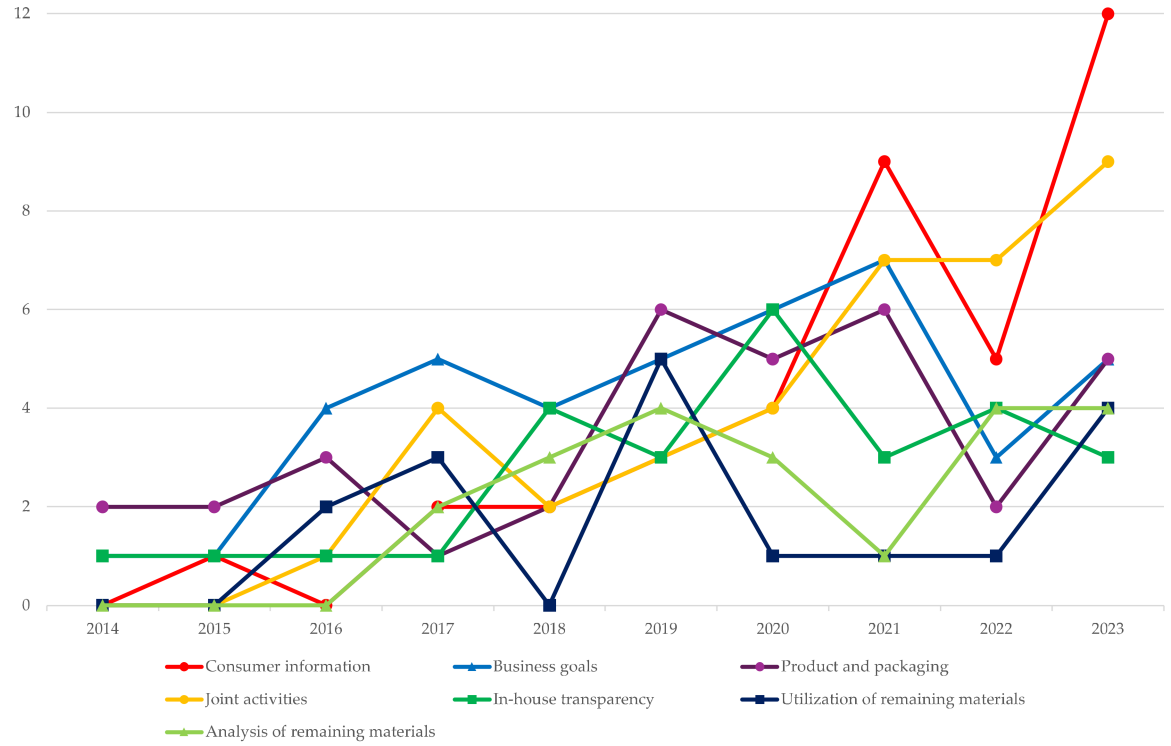

Figure 6. Temporal changes in the communication of themes by food processing companies. Seven selected topics are categorized by year of publication and the number of reporting companies. Note: Data lacking a specific year are excluded from this figure.

Similar to Figure 5, there is a general increase in the number of publications from 2014 to 2023. However, the progression of individual topics varies significantly, with no two topics following the same trajectory. Notably, there is a sharp rise in the publication curves for "Consumer Information" and "Joint Activities". These two topics saw the most significant growth in 2021 and became the most frequently communicated topics from that year onward, making them the dominant themes by 2023.

Earlier, "Business Goals" was the leading topic between 2016 and 2017 but was ultimately overtaken by "Consumer Information" in 2021. Another key observation is the striking changes around 2020 and 2021: consumer-related topics experienced a rapid increase, while topics related to targets, figures, and internal processes saw a noticeable decline. Although internal process-related topics slightly rebounded in 2023, a clear divergence between consumer-focused and internal themes remains. In 2022, most themes in this graph experienced a decline, with the exception of "Analysis of Remaining Materials", which continued to grow despite the overall downturn.

3.5. Commonly Communicated Content About Food Waste

This section is an extension of the previous section and addresses question (ii) by providing more specific content and examples of what the food industry is communicating online about food waste. To do this, the content was summarized and grouped according to the nine areas from supplier to consumer and beyond (see Figure 1).

The results combine the first two areas, "Supplier Level" and "Procurement" and the last two areas, "Other Stakeholders" and "Waste Management Provider" for ease of reference. The common topics are presented in more detail and with examples in the following sections. Not all examples were written in English. Therefore, German examples are translated into English. In addition, the examples are anonymized.

3.5.1. Supplier Level and Procurement

The first area, "Supplier Level", focuses on the topics of suppliers' competence and good cooperation. Companies report that their suppliers play a role in preventing food waste. By supporting suppliers through advisory services, root cause analysis of problems and laboratory testing of quality attributes are reported as measures against food waste. Companies also emphasize the importance of working with their suppliers to help them reduce food waste.

> *"To ensure that raw milk does not have to be discarded for quality reasons, the consultants work very closely with the farmers"*. (Dairy Products, PDF—Press Release, 2021)

> *"The constructive and trusting relationship we have with our growers and suppliers also ensures that resources are managed as efficiently and effectively as possible by eliminating food waste at an early stage"*. (Convenience Food, PDF—Sustainability Report, 2018)

The second area, "Procurement", focuses on the raw material requirements. Companies report on how they are changing their quality standards in purchasing and trying to use other raw materials to reduce food waste in the supply chain.

> *"Adjusting the calibration specifications for fruit and vegetables"*. (Convenience Food, PDF—Sustainability Report, 2021)

> *"Using imperfect fruit [. . .] reduces food waste as we improve the sustainability of our foods"*. (Sugar and Confectionery, Webpage—Blog and Portal, n.d.)

3.5.2. Internal Management

The third area, "Internal Management", focuses on the topics of business strategy, business goals, in-house transparency, and employees.

Companies reported on their commitments to reducing food waste and to the future of our planet and identified food waste as a relevant issue for their business. They committed to contributing to the Sustainable Development Goals through their activities and identified relevant areas within their business. In addition to expressing their commitment, companies described food waste in the context of their business strategies. They described food waste prevention as an important part of their other strategies. In this context, food waste prevention was considered as part of the overall sustainability strategy, as a holistic strategy within the company, or as part of the company's own climate goals.

> *"[. . .] avoiding food waste is an integral part of [. . .] [our] sustainability strategy throughout the entire lifespan of our products [. . .]"*. (Dairy Products, Webpage—Press and News, 2021)

> *"We are actively committed to doing what we can to protect the climate. By using natural resources responsibly, we seek to preserve them for future generations. We work every day to achieve this by reducing CO_2 emissions, plastic, and food waste"*. (Convenience Food, Webpage—Responsibility, 2022)

In addition, companies became more specific about their food waste reduction goals and plans. They talked about their food waste reduction goals in general terms, such as reducing waste by 25% by 2025 or meeting the SDG by 2030. In addition, companies report

on their plans to take action to address food waste. They also shared their plans to achieve their goals and other ambitions to address food waste.

> *"We aim to reduce food waste by 25% in our production by 2025"*. (Convenience Food, Webpage—Sustainability)

> *"Our goal is to halve food waste in our operations and logistics by 2030 compared to 2015"*. (Dairy Products, PDF—Sustainability Report, 2021)

> *"We aim to analyse the waste occurring in our company very precisely in order to develop a concept for further reducing the quantity of waste produced"*. (Convenience Food, PDF—Sustainability Report, 2014)

However, companies also addressed the limits of their food waste reduction goals through legal regulation or food safety. The goals are not always limited to reducing food waste. Some companies also want to raise awareness and encourage action by raising the issue in their company cafeterias to inspire others.

> *"Food waste is a by-product of food production, which cannot be completely avoided and which is subject to strict legal regulations"*. (Dairy Products and Eggs, PDF—Sustainability Report, 2018)

Finally, the companies reported on their success and their achievements regarding food waste reduction by using key performance indicators such as quantities of food waste and the status of reduction. In this context, tables were shown and comparisons with previous years were made. Companies reported on food waste and their performance in their environmental and sustainability reports.

> *"[. . .] we are proud to report that the food waste generated in our operations as percentage of the total volume of food produced was the same as in 2019, 5.7% of total food handled"*. (Convenience Food, Webpage—Blog and Portal, n.d.)

> *"In 2021, we wasted about 31,000 tons less edible raw materials than in 2015"*. (Dairy Products, PDF—Sustainability Report, 2021)

Another topic that the companies addressed was their employees. Companies focused on raising employee awareness on a weekly basis by investing in employee training, strengthening interdisciplinary cooperation, and forming a task force and teams against food waste.

> *"By closely linking the purchasing, planning and sales departments, we try to avoid overproduction and thus minimize food waste"*. (Meat Products and Sausage, PDF—Sustainability Report, 2021)

> *"Team takes on food waste, which then helps advance our goals in food security and climate change"*. (Bakery and Farinaceous Products, Webpage—Process, n.d.)

3.5.3. Internal Processes

The fourth area, "Internal Process", focuses on the topics of raw material handling, measures in the process, and product and packaging.

Companies explained their careful handling of raw materials and their quality control, which was implemented in order to reduce food waste within their company. Activities reported by companies included rework usage, information on improved storage, transportation, processes, and investments.

> *"[. . .] a wide range of tests (varying depending on the product) are conducted on it to ensure perfect quality. [We] [. . .] inspects the raw materials and products in its accredited in-house laboratory"*. (Convenience Food, PDF—Sustainability Report, 2018)

> *"We have a modern inventory management system that tracks all raw materials and semi-finished products at all stages of production. This system also ensures that all products are managed according to the FIFO principle within their shelf life"*. (Meat Products and Sausage, PDF—Sustainability Report, 2021)

> *"In production, new technologies and process improvements are constantly being developed to minimize food loss in the production process"*. (Dairy Products, PDF—Press Release, 2021)

Most of the innovations and technical solutions cited by the companies were product and packaging innovations. In this context, new packaging materials, new packaging concepts, new product labeling, resealable packaging, different package sizes, and better portioning are described as solutions to the food waste problem. Labeling includes explaining the best-before date and printing campaign slogans against wasting food. In addition, some companies describe their products as very effective at reducing food waste because of the way they are made.

> *"[. . .] packaging offers consumers a convenient way to enjoy our products by accurately dosing the optimum amount of product for each serving while reducing food waste [. . .]"*. (Spices, Tea and Coffee, PDF—Sustainability Report, 2019)

> *"We've standardized our labels to "BEST if used by", to help people understand how to best reduce food waste. [. . .] we continue to move to resealable packaging that also helps reduce food waste"*. (Sugar and Confectionery, Webpage—Blog and Portal, n.d.)

> *"A completely new concept to reduce food waste is the new range of smaller bread packs of 250 g–300 g"*. (Bakery and Farinaceous Products, Webpage—Press and News, 2014)

3.5.4. Internal Treatment

The fifth area, "Internal Treatment", focuses on the topics of waste collection, utilization and analysis of remaining materials, and the process of developing measures.

Companies reported on how they deal with food waste when it occurs, how they recycle their food waste and surplus food, and how they use the four "R"s—reduce, reuse, recover, and recycle. To keep food in the cycle, companies recycle their food waste, for example for animal feed, compost, or biogas production. Companies also report donating food that does not meet quality requirements. Another option mentioned was that food left over from the process was used as rework or sold as a by-product to other companies.

> *"In order to counteract food waste, products that do not meet our high quality standards, but which are flawless in the true sense of the word, are GMP-certified and fed into other production cycles such as animal feed production or biogas production"*. (Bakery and Farinaceous Products, Webpage—About us, 2023)

> *"Around the world, we also donate foods that are acceptable to eat but unsaleable due to underweight quantities and less-than-perfect packaging"*. (Sugar and Confectionery, Webpage—Blog and Portal, n.d.)

> *"The optimum way to avoid food waste is to use the majority of end pieces which cannot be sliced to manufacture cubes. The company also sells slices sorted out to the further processing industry"*. (Meat Products and Sausage, PDF—Sustainability Report, 2023)

In addition to the recovery methods that companies described for their surplus food and food waste, some companies described that they regularly analyze food waste by quantity. The amount of food waste generated was compared to baselines, previous years, individual production facilities, locations, targets set, and recovery methods, e.g., sent

for recovery, of which recycled, fermented, used to generate energy, composted, and otherwise recovered. They also report that they are constantly analyzing alternative uses for food waste.

> *"Monthly tracking of food waste (recycled to biogas) with targets"*. (Convenience Food, PDF—Sustainability Report, 2023)

> *"The types of waste are grouped according to 13 different waste fractions and disposal routes, and the achievement of the targets is checked centrally for the entire [. . .] [company] on an annual basis"*. (Meat Products and Sausage, PDF—Sustainability Report, 2019)

> *"Identify opportunities to improve the use of by-products in our already established circular economy in 2022 and on an ongoing basis"*. (Meat Products and Sausage, PDF—Scorecard, 2022)

As a further topic within "Internal Treatment", companies described the basis on which they develop and prioritize their actions. Some companies referred to a systemic process, while others relied on the experience of their employees to develop food waste policies.

> *"This involves close examination of numerous process steps at the location. [. . .] Further starting points to improve earnings are to be found in the size, temperature control and optimum setting of the slicer. Numerous process-influencing variables have already been examined at [. . .] [our company]"*. (Meat Products and Sausage, PDF—Sustainability Report, 2023)

> *"Our employees would like to be involved to a greater extent in various processes, and in addition to improvements at the workplace, they also raise the topics of "Food waste" and "Energy efficiency" as subjects for discussion"*. (Convenience Food, PDF—Sustainability Report, 2018)

3.5.5. Distribution

The sixth area, "Distribution", focuses on the topics of good cooperation with retail and distribution planning.

Beyond the boundaries of the company, the companies provided online information about actions with retailers to avoid or reduce food waste. The companies described close cooperation and coordination with retailers. The measures mentioned that were coordinated with retailers were the coordination of delivery conditions, quantity planning, portfolio, and demand analyses.

> *"Closer coordination with retailers, including through portfolio analysis and joint forecasting, enables products to be produced and delivered at the right time, resulting in longer shelf life"*. (Dairy Products, Webpage—Sustainability, 2023)

> *"Cooperation with retailers has also been further improved in order to be even more precise in the coordination of the quantities required"*. (Dairy Products, Webpage—About us, 2019)

Companies reported on their distribution planning. Information was exchanged on alternative distribution channels for food for human consumption, the secondary market, and the usual marketing to retailers. Examples of the secondary market in this case are factory outlets or bulk buyers such as barracks, hospitals, or canteens. Logistics structure issues were also linked to food waste, with an example of how faster delivery results in food waste avoidance.

> *"Through our digital [...] platform, we continued to sell products with a short shelf life at a discount last year"*. (Dairy Products, PDF—Sustainability Report, 2021)

> *"Solutions included taking action on slow moving stock much earlier by better use of planning and stock-aging tools"*. (Convenience Food, PDF—Food Waste Report, 2020)

> *"With a new logistics platform, we intend to centralize this logistics infrastructure so that we can serve our business partners from a single platform. In addition to improved service, we expect to accelerate processes. One of the consequences of this is that products will reach consumers earlier and therefore have a longer shelf life. [We] [. . .] can thus contribute to avoiding food waste"*. (Meat Products and Sausage, PDF—Annual Report, 2022)

3.5.6. Consumer Level

The seventh area, "Consumer Level", focuses on the topics of consumer information and consumer needs.

"Ten tips to reduce food waste" and "Keep your freezer in check" are content focused on helping consumers in their daily lives. The categories in which tips were given ranged from purchasing and planning over food storage with an explanation of best-before date to how to check the edibility of food with your own senses and tips for a sustainable lifestyle. These tips are combined with the benefits of money saving, a healthy diet, and sustainability. Some companies offer workshops and seminars for consumers on cooking techniques and food waste in addition to just tips.

In addition to general tips on storage and purchasing, the companies offered additional help in the form of recipes. Inspirations for leftovers were given, such as "You can use. . . to create. . .". Furthermore, companies supplied complete recipes and even recipe databases that described the usage of leftover food as ingredients. In some cases, the companies' products were also used in these recipes. The tips and recipes were published both on the websites and in the form of separate documents containing only consumer tips.

Furthermore, some companies encouraged visitors to their websites to take part in challenges to reduce food waste. These challenges were associated with hashtags on social media, part of a company's own campaign, or related to other initiatives and organizations.

"One-third of all food produced globally is lost or wasted", "1.3 billion tons of food is wasted every year", and other similar phrases were communicated about food waste. These contents were used by companies to inform and educate about food waste in general. The companies inform the reader about the global amounts of food waste, the consequences of food waste, the environmental risks, CO_2 emissions, resource and land consumption, and the general importance of reducing food waste. The companies also explain how food waste relates to food production and the dilemma between safety and waste reduction.

Furthermore, companies reported on news regarding food waste from around the world. New studies on food waste were presented, and interviews with people who have an opinion or something new to report on the subject were published. This includes reports on innovative start-ups and pilot projects with new products and new methods. Companies also share information on trends, new media such as cookbooks, events, and general information about campaigns and initiatives.

> *"Delicious meals can be made from the previous day's leftovers. Not only is this sustainable and saves on grocery shopping, it also tastes great"*. (Fish and Seafood Products, Webpage—Blog and Portal, 2023)

> *"No one can save the climate alone, but everyone has a responsibility and can do their part. Here are some ideas and tips for living a greener life: from your personal carbon footprint to smart shopping, creative cooking to food saving. Join the fun!"*. (Dairy Products, Webpage—Sustainability, 2023)

> *"Did you know that 17% of all food ends up in the bin? According to the UN, 17 per cent of all food at consumer level ends up in the trash. That is 17 percent too much. And in fact, food waste accounts for up to 10 percent of the world's CO_2 emissions. That is why it's important to fight food waste. For example, by using our senses and our sense before throwing food away"*. (Meat Products and Sausage, Webpage—Sustainability, 2023)

In addition, companies reported that they pay attention to customer needs. To this end, customer surveys were conducted on individual products, and customer feedback and requests were incorporated into product development and improvement.

> *"In order to build this deep consumer understanding, the brand launched some of the largest and longest intervention studies in the area of household food waste in collaboration with leading experts and behavioural economists [. . .]"*. (Convenience Food, Webpage—Press and News, 2022)

> *"We regularly carry out customer surveys on individual products and incorporate the feedback into our product development"*. (Convenience Food, PDF—Sustainability Report, 2015)

3.5.7. Other Stakeholders and Waste Management Providers

The last two areas, "Other Stakeholder" and "Waste Management Providers", focus on the topics of business-to-business exchanges, joint activities, and continuous inspection of the disposal service. Another measure mentioned by companies was the sharing of their search for use and symbiosis opportunities with other companies.

> *"The cooperation with [. . .] [company], which started at the end of 2022 and is to be expanded in 2023, now offers further opportunities [. . .] to make good use of surplus food"*. (Convenience Food, Webpage—Press and News, 2023)

> *"[. . .] we have continue our partnership with [. . .] [company], and we were able to reduce tons of greenhouse gases from the environment. We are continuously working with [. . .] [company], to work together to make [...] [our company] to become zero waste businesses"*. (Beverages, Webpage—Press and News, 2020)

In addition to sharing information with other individual companies, companies also reported on joint activities. These joint activities included working with NGOs, running joint campaigns, supporting campaigns, and partnering with community organizations to raise awareness and increase the impact of activities. The companies also explained their extensive work with food banks and their involvement in food waste research projects.

Companies informed with "We commit to the . . . initiative", and "We support the campaign . . .", and "We are a founding partner of. . ." about their membership and entry in campaigns against food waste. Information was provided on various campaigns in which the companies were involved as members. Some campaigns focused on reducing food waste at the consumer level or in public institutions or were charitable programs interested in the companies as members. One of the most frequently mentioned collaborations was with the "TooGoodToGo" initiative, but collaboration with schools and universities was also mentioned.

> *"We collaborate with the company Too Good To Go to fight food waste"*. (Meat Products and Sausage, Webpage—Sustainability, 2023)

> *"To raise awareness and set an example for sustainability as a family business, we are partnering with TooGoodToGo and participating in the "Often good for longer" campaign"*.

> *"[We] [...] [and the name of the NGO] join forces to help charity cooks get inspired in the kitchen with their donations"*. (Dairy Products, Webpage—Blog and Portal, 2021)

> *"On Food Waste Day, [...] [our company] is also supporting the [...] initiative of the environmental and conservation organization WWF, which is using the occasion to highlight solutions to the problem of food waste"*. (Dairy Products, PDF—Press Release, 2021)

In addition to other stakeholders, NGOs, and initiatives, waste service providers were also involved in this issue. In this context, the cooperation with selected waste management companies and the guarantee of professional service quality were emphasized.

> *"They ensure professional transportation, recycling and disposal by working with selected waste and disposal service providers"*. (Meat Products and Sausage, PDF—Sustainability Report, 2019)

3.6. Detailed Analysis of Messages in the Consumer Information

This section answers RQ (iii), to what extent are companies implementing communication recommendations on food waste messaging to increase consumer awareness and intention to reduce food waste? This is aimed at gaining a deeper understanding of how consumers communicate. A total of 47 documents were identified through the comprehensive literature search. After screening for recommendations on food waste messaging to increase consumer awareness and intention to reduce food waste, a total of 6 peer-reviewed articles were found that provided messaging recommendations (see Section 2.5). The messaging recommendations contained in the peer-reviewed paper were categorized and used to create a category system for subsequent indicative content analysis. Table 5 shows the system of three common messaging recommendations to increase consumer awareness and intention regarding food waste. The most common recommendation in the literature is environmental messages (n = 6), describing the negative impact of food waste on the environment and the planet, which can refer to different aspects, resource consumption, CO_2 emissions, etc. Other recommendations are food security messages (n = 3). Other recommendations include food security messages (n = 3) and financial messages (n = 2). Food security messages focused on hunger, availability, and morality. The financial messages recommendation shows how much everyone can save by avoiding food waste.

Table 5. Recommendations for food waste messaging to increase the awareness of consumers and their intention to reduce food waste.

Recommendation	Description	References	No.
Environmental messages	Describe the negative impact of food waste on the environment.	[25–27,68–70]	6
Financial messages	Describe the financial burden of food waste.	[68,69]	2
Food security messages	Describe the food security concerns associated with food waste.	[26,27,70]	3

In order to show how many companies are already implementing these recommendations for food waste messaging, these three recommendations were used to analyze the information from the category "Consumer Information" category. The following results show how many companies that provide consumer information have implemented these recommendations. Due to the small number of companies, a breakdown by subsector has not been provided.

In general, 54% of the companies (n = 25) had consumer information regarding food waste on their websites (see Section 3.3). The analysis shows that 12 of these 25 companies (48%) have implemented at least one of the recommendations in their consumer information. The actual range of implemented recommending messages was between 1 and 3, with a median of 2. A total of 50% of companies used all three recommendations in their communication, 42% used only two, and 8% used only one message.

Figure 7 shows the number of companies that used messaging recommendations to increase consumer awareness and intention to reduce food waste. The diagram shows the recommendation from Table 1 (see Section 2.1) and the number of companies that used that recommendation in their consumer information. Companies were counted only once per recommendation.

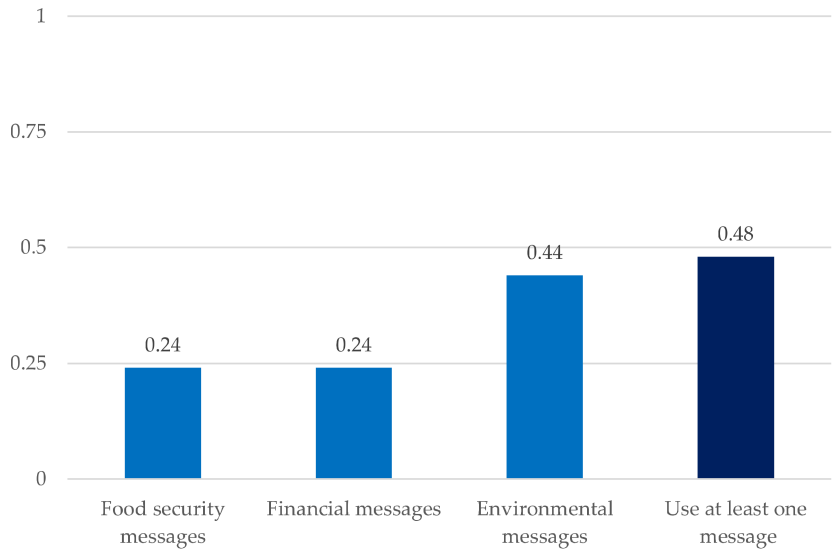

Figure 7. Extent of implementation of communication recommendations to enhance consumer awareness and motivate actions to reduce food waste through consumer information. Communication ranges from 0 (not used by companies) to 1 (used by all companies providing consumer information, $n = 25$).

All recommendations for effective messages in consumer information were used by the companies. The most frequently used messages in consumer information are the environmental messages (44%). The other two messages, food security messages and financial messages, are used equally often (24%) by the companies that used consumer information. The messages could be found in food waste prevention tips, reports, and general information about food waste. The financial messages were also combined with environmental messages. For example, "You can save not just resources, but also your money". Other environmental messages also targeted CO_2 and the fact that we only have one planet. The food safety messages regarding world hunger and the global hunger crisis. Food security messages include the issue of world hunger. This emphasizes the urgency of avoiding food waste at home.

Most of the documents containing these messages were published in 2020 (25%), 2021 (25%), and 2023 (20%). In 2019, there were no documents published with messages, and in 2022 (5%), messages were also hardly used. This shows a similar picture to the number of publications by year of publication (see Figure 3). Looking at the individual messages over time, from 2020 onwards, all the themes show an increase in popularity. However, the environmental messages were always more present than the other messages. In 2022, all messages declined. In 2023, more messages were used again, although most of these were environmental messages. The other themes continued their downward trend. As a result, the messages on food security and the financing of food security after 2023 are of secondary importance.

3.7. Assessment of Food Waste Communication

This section presents the assessment of the status quo and topics. The results show whether the topics were selected based on how they were implemented and how effective

they were. Finally, the last section presents the assessment of the status quo in terms of its relevance to the National Strategy for the Reduction of Food Waste.

3.7.1. Assessment of the Choice of Themes

This section answers RQ (v) on whether self-assessment of the implementation and effectiveness of food waste measures play a role in the choice of topics communicated. For this purpose, the results of the status quo of communicated actions against food waste from Section 3.3 were used and compared with the results of one of our previous studies on the status quo of implementation of actions against food waste in the food processing industry and their effectiveness and feasibility [19]. The data were collected in our previous study using an online questionnaire. The questionnaire allowed companies to self-assess the implementation of measures in their organization and to rate the measures themselves in terms of effectiveness and feasibility. The results show the companies' self-assessment of the topics. Effectiveness and feasibility results were combined. The rating was on a scale of 0 = not implemented/not effective and feasible and 1 = fully implemented/highly effective and feasible. A mean value of 0.75 was taken as the critical threshold for classifying practices as mostly established/effective/feasible. Measures with a score below 0.75 were considered moderately effective and feasible.

The results are shown in Figure 8 as a scatter diagram. On the *x*-axis, the status quo of the communication level ranges from 0 (not addressed by companies) to 1 (addressed by all companies). On the *y*-axis, the status quo of implementation ranges from 0 (not implemented in the food processing industry) to 1 (fully implemented in the food processing industry), according to Rösler et al. [19]. As in the other sections, the results are presented in the form of summarized categories.

The comparison of the communication level (*x*-axis) with the implementation (*y*-axis) of actions against food waste in the food processing industry shows no recognizable curve. However, the diagram can be divided into four areas. In the top left area are the categories that are implemented more than 50% but communicated less than 50%. In the bottom left area, the diagram shows the categories that are implemented very little and communicated very little. The bottom right area shows the categories that are communicated more than 50% but implemented very little in the industry. Finally, in the top right area, the diagram shows the categories that are more than 50% implemented and communicated in the industry.

Most of the categories are located in the top left area, including 16 out of 22 categories. This shows that most categories are well implemented in the industry, but little is communicated about them. The bottom left shows a similar situation where the topics are just as little communicated but also less implemented in the industry. This area includes the topics "Good Cooperation" with suppliers (0.20; 0.45), "Continuous Inspection" (0.02; 0.32), and "Joint Activities" (0.46; 0.45). There is one category, "Consumer Information" (0.54; 0.46), in the bottom right area that is highly communicated but less implemented in the industry. The last area, the top right area, shows the topics "Business Goals" (0.50; 0.75) and "Product and Packaging" (0.54; 0.86), each of which is implemented and communicated in the industry by more than 50%.

The figure shows that the choice of the most frequently communicated topics is not always the same as the topics that have already been implemented in companies. Although "Product and Packaging" is one of the most implemented and communicated topics, there are counterexamples. "Consumer Information", for example, is just as often communicated but not as often implemented. There is no correlation between the fact that the issues that are communicated most often are the same as those that are implemented in companies.

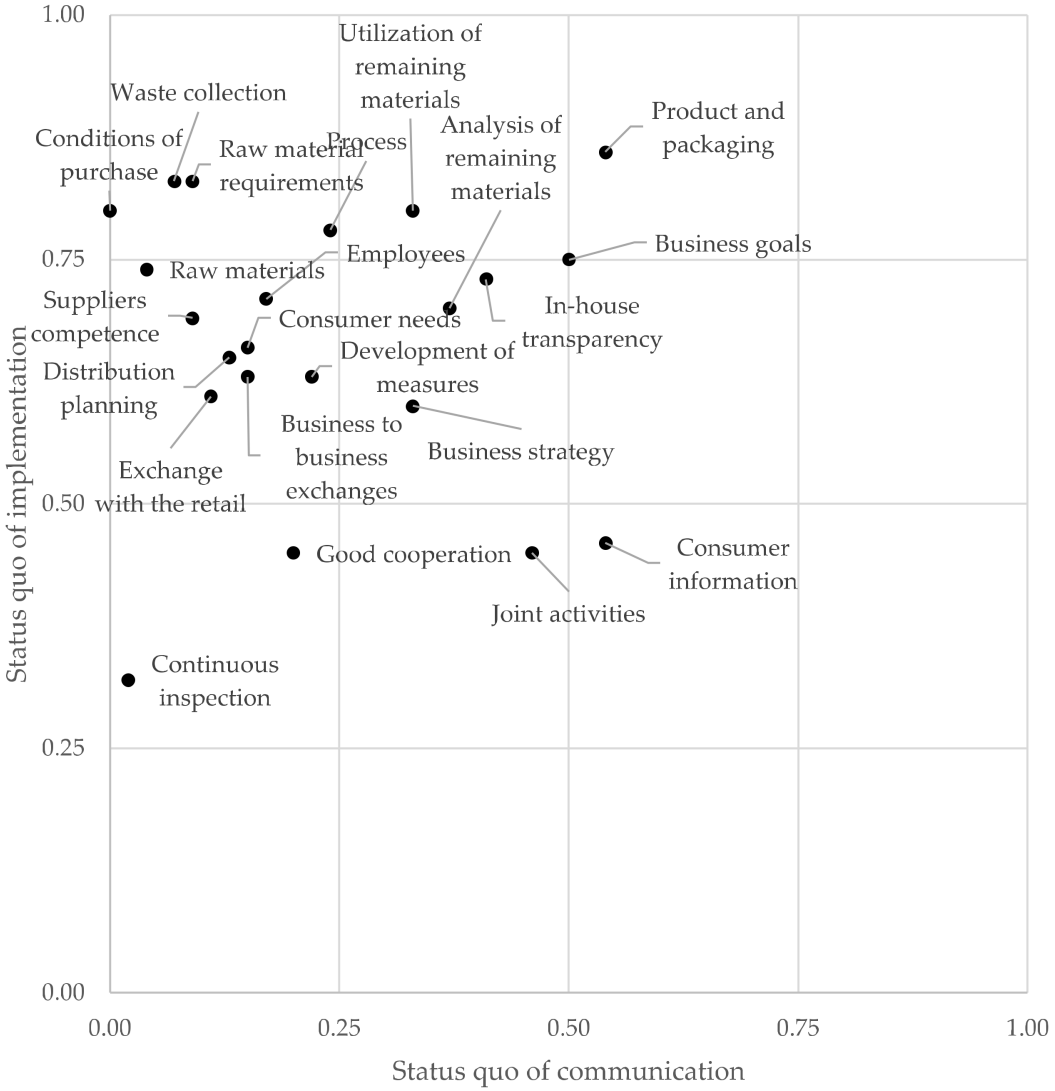

Figure 8. Relationship between the current communication level and the implementation level of the categories as defined by Rösler et al. [19]. Communication ranges from 0 (not addressed by companies) to 1 (addressed by all companies) (n = 46). Implementation ranges from 0 (very low) to 1 (very high).

Another comparison is made between the level of communication and the mean value of the effectiveness and feasibility of the actions against food waste, according to Rösler et al. [19]. Figure 9 shows the comparison as a scatter plot. On the x-axis, the status quo of the communication level ranges from 0 (not addressed by companies) to 1 (addressed by all companies). On the y-axis, The mean value of effectiveness and feasibility ranges from 0 (very low) to 1 (very high).

The comparison of the communication level (x-axis) with the effectiveness and feasibility (y-axis) shows a similar picture to the comparison with the level of implementation (see Figure 8). The scatter plot shows no recognizable curve. However, the figure can also be divided into four areas. The top areas are the categories that are effective and feasible, and the right areas are the categories that were most communicated. It shows that all categories have moved slightly upward. Once again, the top left area contains the largest number of categories, including 18 out of 22. The bottom left area contains only the category "Continuous Inspection" (0.02; 0.46), and the bottom right area is empty.

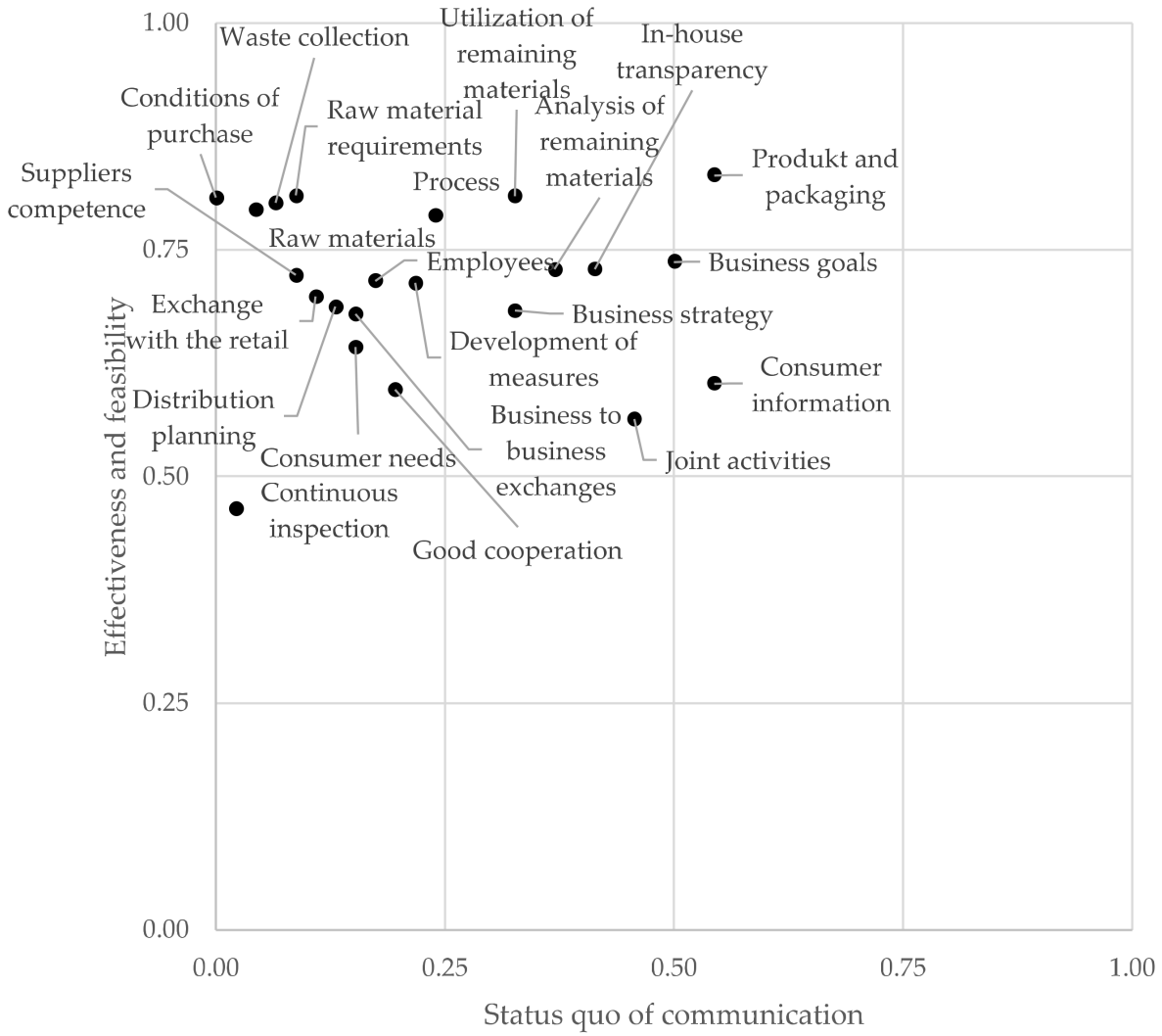

Figure 9. Relationship between the current communication level and the level of effectiveness and feasibility of the categories, according to Rösler et al. [19]. Communication ranges from 0 (not addressed by companies) to 1 (addressed by all companies) (n = 46). Effectiveness/feasibility ranges from 0 (very low) to (very high).

The top right area includes the categories "Consumer Information" (0.54; 0.60), "Business Goals" (0.50; 0.74), and "Product and Packaging" (0.54; 0.83). These categories are both addressed by over 50% of the companies and reported as effective/feasible by over 50% of the companies.

3.7.2. Assessment of the Status Quo in Terms of the National Strategy

This section answers RQ (vi), are companies prioritizing communication in relation to the German National Strategy for the Reduction of Food Waste, or is there a need for action? For this purpose, the priority clusters were compared with the communication status quo to assess current communication and identify any action required. To do this, the clusters from Section 3.1 were compared with the results from Section 3.3. The results are shown in Figure 10 as a scatter diagram. On the x-axis, priority topic clusters range from 5 (low priority) to 1 (high priority), according to Figure 2. On the y-axis, the status quo of the communication level ranges from 0 (not addressed by companies) to 1 (addressed by all companies).

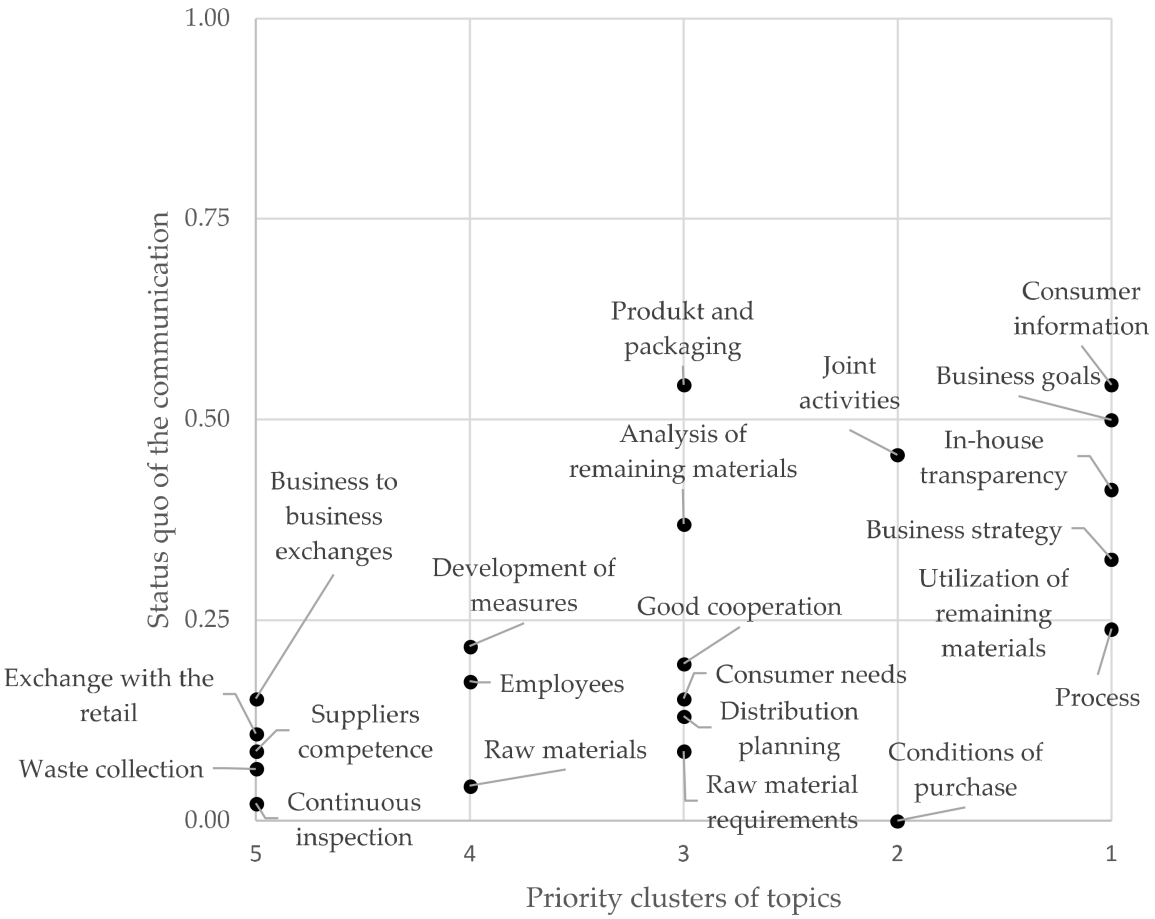

Figure 10. Distribution of topics according to the status quo of the communication level and the priority topic clusters from Figure 2. Communication ranges from 0 (not addressed by companies) to 1 (addressed by all companies). Priority topic clusters range from 5 (low priority) to 1 (high priority).

The comparison of the priority clusters (*x*-axis) with the communication level (*y*-axis) of actions against food waste in the food processing industry shows an almost linear increase with outliers between Clusters 5 and 1. This is also reflected in the calculated average for the status quo per cluster. The averages for the status quo of each cluster are Cluster 1 (39%), Cluster 2 (23%), Cluster 3 (25%), Cluster 4 (14%), and Cluster 5 (9%). As the priority increases, so does the frequency with which topics are communicated. Companies, therefore, communicate most topics from Cluster 1, "must-haves". In contrast, there is a large variation between Cluster 2 topics, ranging from no communication at all to the highly communicated topic, "Joint Activities". Clusters 3 is on average more frequently communicated than 2 and contains one of the most frequently communicated topics, "Product and Packaging". The last cluster, 5, is the least implemented cluster. Apart from the outliers in Cluster 3, the last three clusters (5, 4, and 3) are equally well communicated. It appears that companies have already aligned their choice of topics with the interests of the national strategy. They communicate topics from clusters with a higher priority more often than topics from clusters with a lower priority.

4. Discussion

Six topics, "Business Goals", "Business Strategy", "Process", "Consumer Information", "In-house Transparency", and "Utilization of Remaining Materials", have been identified as having the highest priority for communication according to the national strategy, a finding that addresses RQ (i). In total, 43.8% of the companies analyzed communicated about food

waste on their websites, a finding that addresses RQ (ii). To answer RQ (iii), the analysis shows that 21 out of 22 topics were addressed by the companies. The most common communication topics, the top three, which are communicated by half or more of the companies, are "Product and Packaging" (54%), "Consumer Information" (54%), and "Business Goals" (50%). To answer RQ (iv), 48% of 54% of the companies that communicate "Consumer Information" have implemented messaging recommendations to increase consumer awareness and intention to reduce food waste. A comparison of the measures implemented in the industry and the frequency with which these measures are communicated revealed that many measures that are well implemented are not communicated to the same extent, a finding that addresses RQ (v). Two topics stand out as being both well implemented and well communicated in the industry. These are "Product and Packaging" (0.54; 0.86) and "Business Goals" (0.50; 0.75). It was found that companies communicate content that is highly relevant to the national strategy more often than content that is considered of lower priority, a finding that addresses RQ (vi).

The selection of topics in Cluster 1 shows that the focus for businesses is on targets, facts, data, solutions, and consumer information (see Section 3.1). Through "Business Goals", "Business Strategy", "Process", and "In-house Transparency", it would be possible to monitor progress and efforts over the years with facts. The chosen food waste paths would also be visible and comparable through the "Utilization of Remaining Materials". "Consumer Information" is also seen as an integral part of the company's business. This selection supports the national strategy through transparency and information and leads to the desired improvement in data quality [30]. The response in the questionnaires that companies should distinguish between edible, non-edible, avoidable, and unavoidable food waste should be added here. A key conclusion is that companies should be transparent about their targets and results and that they should also support consumers in the prevention of food waste. These findings also support international calls, such as in the US and France, to close the data gaps in the processing sector [6,31].

Almost half of the companies (43.8%) use the term food waste on their websites. Gorgan et al. find a similar rate when analyzing annual reports of organizations across the food value chain [23]. In 2016, Richter et al. [10] found that companies do not communicate about food waste because they consider organic production and sustainability to be more appropriate topics for consumer communication. This is an important finding in that this is no longer the case and has changed over the last 8 years since 2016, which is an important finding. Although not all companies report on food waste, more than half of the companies (n = 59, 56.2%) do not provide any information on food waste. The reasons for this can only be speculated, but the time and human resources required may simply be too great for these businesses. Another assumption is that companies do not see it as their responsibility to inform consumers, as 90% of companies surveyed in an online poll said that the government should take care of consumer education [71]. However, consumer information is only part of the food waste communication. The largest sectors not communicating are beverages (n = 12, 22%) and meat (n = 12, 20.3%). These two sectors also had the highest number of companies. The fact that the drinks sector communicates so little may be due to its own assessment that it has 0% food waste in production [71]. Parallels could be drawn with the meat sector, where by-products are used in a variety of ways. The sample includes many large companies with more than 1000 employees. It can be assumed that companies of all sizes communicate about food waste in a relatively consistent way.

In total, 90 references were cited in 216 documents, with some documents containing multiple references. Companies often describe the relevance of the topic without citing explicit sources or using links to general websites. This could be interpreted as meaning

that the issue is already established and does not require much persuasion to explain its relevance or that a lot of information simply does not need to be referenced. Nevertheless, a request for companies to talk about official government information, such as the Food Waste Pact, was included in the questionnaire responses. However, the distribution of companies in terms of topics and the wide range of documents per company (between 1 and 20 documents) shows that companies communicating extensively on food waste are rather the exception. When the analysis is narrowed down, and only those companies are considered that have consumer information on their websites. It turns out that only a fifth of companies (46% of 43.8%) provide consumer information about food. To avoid misunderstandings, this needs to be clearly distinguished.

The distribution of the status quo of communication partly reflects the results of previous studies showing that companies tend to implement actions internally [23,71] (see Figure 3). However, the results show that companies do not just communicate about themselves but also provide information to customers or highlight other actors who are doing something about food waste. The current results show that internal actions are communicated, and actions at the end of the food value chain are more likely to be emphasized than actions at the beginning of the value chain related to supplier and purchasing information. With consumer information, companies focus on communicating actions at the end of the food value chain. One reason why companies continue to emphasize their own actions is that they tend to see the causes of food waste within the organization, and companies' perception is that borders to outer stakeholders are not a problem, perhaps because coordination is the most commonly implemented measure [71]. It is reasonable to assume that the causes are rarely to be found at the borders because these measures are established or part of the routine. In contrast, internal measures are rarely implemented [71]. Nevertheless, the results show that the individual topics are communicated differently depending on the subsector of the companies.

The three most important topics communicated were "Product and Packaging", "Consumer Information", and "Business Goals", which seems to be a reasonable selection. As food waste communication faces several expectations, the results show that current communication with the top three topics can meet these expectations. One expectation is that companies should develop products and improve processes based on insights into consumer behavior [18]. Companies do this by communicating "Product and Packaging" (54%). They should aim to improve the consumers' food management skills and raise awareness of the issue of food waste [9,10]. To this end, companies provide "Consumer Information" (54%). Furthermore, companies should also provide information regarding their activities and commitment to avoid food waste [10]. They do this by reporting on "Business Goals" (50%). These are all issues that the national strategy calls for, such as the inclusion of food waste prevention as an objective in companies' internal strategies and appropriate packaging to protect food from spoilage and to inform consumers [4]. Another study found that companies provide a lot of information to consumers but less about packaging and products [23]. It seems that communication about packaging has become more and more important. However, as mentioned above, when it comes to communicating about food waste in terms of "Consumer Information", only a fifth of companies are willing to share information (46% of 43.8%). This is much lower than the companies' self-assessments of 46% [19]. Therefore, it must be assumed that there are other consumer information activities and that online communication on websites is not the only activity. This could include social media, magazines, e-newsletters, product stickers, and so on [16]. However, communicating with consumers is only a small part of communicating about food waste. The data would fit together if all communications on food waste were included.

While not all the content is intended for consumers, the following two more detailed looks suggest that it is. A closer look at another area in which companies are specifically targeting the avoidance of food waste in households is the category of "Products and Packaging". Companies report a lot about their packaging and packaging innovations. However, companies face a few challenges with this content. The difficulty in communicating improved packaging is that reducing plastic is perceived by consumers as more important than reducing food waste [72]. Consumers are unaware of the benefits of food packaging in the home and do not see a direct relation between packaging, shelf life, and spoilage [73]. Consumer purchasing behavior is very complex. Obersteiner et al. [73] point out that packaging is only a small part of the purchase decision compared to quality, price, etc. However, improved packaging is important to prevent food spoilage [73]. Companies must find a balance between packaging waste and food waste [74]. Chan et al. [74] suggest that a lack of communication with consumers and a language gap within the industry are among the reasons why packaging is not seen as a way to reduce food waste. Obersteiner et al. [73] emphasized the importance of educating consumers about the benefits of packaging features to help avoid wasting food. This raises the question of whether information on packaging is really something that is aimed at consumers, given that the questionnaire states that the company should reduce packaging.

A further in-depth look, this time at the area of "Consumer Information", shows that businesses are not making full use of their potential to assist consumers. Recognizing that the most effective way to increase consumer awareness and intent is through environmental, financial, and food safety messages [26,69] and that only a few companies are using these messages (48% of 46%) (see Section 3.6). The most common recommendation for increasing consumer engagement is the use of "Environmental Messages", which are used by 44% of companies that provide "Consumer Information" (54%). In addition, consumers' emotions play a role in their perception of the message, and anxiety can reduce the effectiveness of the message [75]. However, it must be assumed that consumers are completely unaware of the consumer information on websites and do not take any notice of it. However, food waste communication will also not be effective if it is perceived as a branding or marketing tactic, and it is fundamental to communication that consumers trust the messenger [76].

Communicating about food waste can have a positive impact on consumers, raising their awareness [10,16]. Furthermore, when companies talk about preventing food waste, it can improve the perception of their products [77]. Messages with moral appeals, such as environmental and food safety messages, should be used if companies want to raise consumer awareness of food waste [27]. Compared to no message, content about meal planning, or delicious food, environmental messages can increase participants' intention to reduce food waste [69]. In addition, Bretter et al. show that environmental messaging is shown to be as effective as messaging about the financial costs of food waste [69]. This means that financial messages are no more effective than environmental messages [69]. According to Bretter et al., environmental messages that emphasize responsibility can encourage participants to reduce food waste [69]. However, it turns out that environmental concerns are more likely to appeal to customers who are generally altruistic [26], and it is also not possible to generalize that environmental messages always lead to a reduction in food waste [69]. This shows that companies need to adopt a broad communication strategy to increase consumer awareness and intention to reduce food waste [69,70,78]. Consumer waste is a transdisciplinary issue [68]. Companies should not choose a strategy that neglects health and food safety concerns, as these act as barriers [68]. Communication must, therefore, also be about the fact that a product is safe even after the expiry date [79]. There is a possible link between labeling confusion and food waste; for example, products with a use-by date and only one date were consumed less than products with a best-before

date [80]. As mentioned above, some results show that consumers perceive packaging waste as a more serious environmental problem than food waste [72]. It can be particularly difficult for companies to use environmental messages to encourage consumers to think about food waste while, at the same time, explaining more packaging. A dilemma that has been mentioned several times. This requires communication skills. However, knowing and becoming aware of food waste does not make people more willing to act [25]. When it comes to food choices, consumers say that price, taste, and health are more important than sustainability [81]. Therefore, consumer information alone cannot solve the problem at the household level. Aschemann et al. [70] emphasize that measures against consumer-related food waste are only expected to minimize, not eliminate, the problem. Nevertheless, the message does not reduce intentions or interest in efforts to reduce food waste [69] and might lead to more trust in the company.

The changes in communication over time (Section 3.4) show that the issue has become more relevant to companies in recent years, as has the importance of communicating about food waste, which also shows that most documents found (55.1%) could be dated between 2020 and 2023. On the assumption that companies keep their websites up to date, the undated pages could also be counted as current dates, which would increase the proportion to 75% (n = 162). Figure 5 shows exactly how the number of publications has continued to increase over the years and how more and more companies are communicating about food waste. From 2020 onwards, the number of publications increased even more than the number of publishers. From that point on, companies communicated more content at the same time. The European Union's Green Deal seems to have motivated some companies to address food waste [23]. Whether the introduction of the 'International Day of Awareness of Food Loss and Waste' in 2020 has anything to do with this increase can only be speculation [22]. Only in 2022 was there a break in the graph. The decline in publications can most likely be linked to the multiple crises that have hit the food industry, such as the supply chain difficulties caused by the COVID-19 pandemic and the increase in energy, logistics, and raw material prices caused by the war in Ukraine [82]. Companies reported that food waste prevention is becoming more important due to the war in Ukraine (51.9%) and that COVID-19 has had no impact on their food waste (79.3%) [19]. It was not until 2023 that the topic became popular again, and even more so than before, probably because of a catch-up effect and a continued increase in public interest. In 2022, the Federation of German Food and Drink Industries also signed the national strategy agreement [83]. In addition, food companies rated the extent to which the importance of sustainability in their organization has changed in 2022/2023 as high, at four out of five [15]. It could not be conclusively determined why there was an increase in the number of communicating companies in 2018, which were also communicating for the first time.

An examination of each of these topics over time shows the trends over time and the future direction of communication (see Section 3.4 and Figure 6). It also shows that the individual topics will continue to grow in importance. This is evidenced by the fact that sustainability has become increasingly important to companies in recent years [15]. However, there is also a shift in priorities between 2020 and 2023. The communication strategies show a shift over time from a data focus to a consumer focus. As mentioned above, the coronavirus pandemic and the war in Ukraine are likely to have reduced communication on many issues in 2022. In 2023, many topics experienced a small renaissance. However, the biggest increase was in consumer-facing content such as "Consumer Information" and "Joint Activities", while process and other information about the company decreased. Perhaps this is because sustainability is most closely associated with management and PR, and consumer information is precisely the tool of corporate communications [15]. The downward trend shows that other stakeholders should start making demands again.

Otherwise, the factual situation could get worse. Levenert et al. report a response rate of only 3.4% for food waste data and see a data gap in the processing and manufacturing sectors [30]. In this context, it can no longer be assumed that there will be an automatic improvement in the data situation, as predicted by Leven et al. [30]. Especially given that companies see politics and NGOs as the biggest drivers of sustainability [15]. This is not an indication of a voluntary commitment. The future direction of content will be consumer-driven if the trend in topics continues. This is even though companies see consumer information as a political responsibility [71].

The results show that the choice of the most frequently communicated topics is not related to their effectiveness, feasibility, or implementation (see Section 3.7.1). This was confirmed by comparing implementation and effectiveness with the frequency of communication. Although "Product and Packaging" is again one of the most effective and feasible topics and is communicated most frequently, there are other examples. Other topics, such as "Consumer Information", are communicated just as often but are perceived as less effective. Apparently, neither implementation in the company nor effectiveness and feasibility play a role in the selection of topics. Data on implementation and effectiveness based on companies' self-assessment [19]. Although companies tend to see the causes of food waste internally [71], there is a slight imbalance between implemented and reported measures. The perspective on measure assumptions may also change depending on the position of the stakeholders in the supply chain [84]. Therefore, one explanation for the tendency to communicate selected topics could be that companies tend to focus on public relations or branding issues rather than internal company details. Implementing measures to reduce food waste often faces barriers such as customer requirements and acceptance, as well as costs and time that companies must overcome [19]. Communicating actions would tie up additional company resources. This may also be the reason why not all frequently implemented measures are communicated, but only a selection.

The distribution of topics by cluster shows that companies have already aligned their choice of topics with the national strategy, which is an important finding. They are more likely to communicate topics from the higher priority clusters than from the lower priority clusters. Nevertheless, the rate of communication on all topics is very low in relation to the total. The key themes of Cluster 1 need to be further developed, and companies need to be encouraged to be more transparent about the national strategy. No companies addressed the topic of "Conditions of purchase" in relation to food waste. This topic belongs to Cluster 2 and should be given more attention by companies. It has been shown that one of the most communicated topics is assigned to Priority 3, "Product and Packaging". The strategy involves changing behavior and raising public awareness, as well as communicating its own objectives. However, the clusters show that there is a strong desire for transparency and data. Companies need to improve their communication and provide data. A comparison of the topics communicated by the companies with the generally effective measures to reduce food waste, according to a survey in the USA [85], shows that the selection of companies seems reasonable. Companies are addressing all the key issues, according to Fan et al., such as food packaging, portion sizes, date labeling, imperfect products, donations, inedible food for animal feed, composting, and consumer education [85]. However, this selection does not fully support the national strategy, which wants transparency and facts. Expectations are, therefore, high for companies to elaborate on their issues. They are expected to provide information on their objectives, processes, use, results, and consumers.

4.1. Theoretical Implications

The results are not only applicable to Germany because the companies in the study are internationally active, and the analysis was based on their English-language websites.

In addition, other national and international strategies, such as those of the US and the EU, emphasize the importance of partnerships with the private sector to achieve goals [6,7]. The US also identifies and discusses data gaps and constraints in the processing sector as barriers to understanding the extent of food waste and measuring the success of interventions [6]. Data for the upstream processing chain are also very limited in France and in the EU [31]. In addition to communication and collaboration, robust data are a critical success factor [12]. In the future, the European Union's Sustainability Reporting Directive (CSRD) could make reporting increasingly even more urgent. This would not only have an impact on German companies. The European Union puts sustainable reporting on par with financial reporting [20]. Although not all businesses will be affected by this reporting requirement, even the smallest businesses may be required to report on relevant issues if requested by their customers [86] or if they are willing to voluntarily support the National Strategy for the Reduction of Food Waste [4]. More open and transparent communication about food waste would also make it easier to conduct research.

The pressure on companies to be more transparent could lead to more action on food waste, such as greater use of big data and artificial intelligence. This technology is still used very little in food processing companies, for example for forecasting [87]. Artificial intelligence, the Internet of Things, machine learning, and big data can make a big difference. They provide sensor readings that monitor food quality, support food logistics, and provide real-time analytics [88]. They enable data visualization and collaboration [87,88]. The technology improves defect detection and resource flows and optimizes processes to reduce food waste [89]. These technologies, therefore, promise greater transparency if processes can be better monitored and data can be automatically processed and analyzed. This could also simplify and standardize reporting, especially in relation to communication with other stakeholders. Companies should, therefore, take advantage of technology to improve transparency and communication.

The results show that reporting on food waste is already in place and is likely to become more important due to the media and political attention they receive. Companies need to make this more visible or clearer. The argument that companies are just waiting for consumers to care about food waste should no longer apply [10]. Food waste is an issue of interest to many stakeholders, not just consumers. However, the latest trend in the food industry is the increased distribution of consumer information about food waste. It is not just that communication influences consumers. It is also that consumer behavior and feedback shape companies' strategies. Discussions between consumers about sustainability can encourage other consumers to make their purchases more sustainable [90]. Companies will have to adapt. 66% of companies already actively seek consumer feedback to identify consumer needs [19]. However, companies also face many challenges in implementing greater sustainability. These include, in particular, customer demands and other market dynamics [91]. The link between lifestyles and food waste flows is forcing companies to adapt their customer communication strategies [92]. Furthermore, the democratic transition and the increase in the number of single-person households also show that companies need to adapt their strategies [93]. The results showed that companies are already responding to consumer behavior and changes by adapting their packaging. To this end, consumers should also be encouraged to demand information and transparency from companies. Communicating about food waste can lead to competitive advantage for companies through image improvement [10,14] and help improve perception of products [13]. By recognizing the competition and influence of consumer behavior, other companies could make their own communications more transparent and clearly address the issue of food waste. However, communicating about food waste should build trust and be more than a branding or marketing tactic [76]. Otherwise, information about food waste will ultimately be regarded

as mere marketing rhetoric. Nevertheless, it is important to focus on the future direction regarding transparency and the closing of data gaps.

4.2. Practical Implementation for Policymakers

The clustering of topics provides a basis for further policy decisions and cooperation between stakeholders, as well as an opportunity to professionalize communication in line with the objectives of the national strategy. Cluster 1 could be a starting point for policymakers to improve transparency through a call for better communication on these must-have topics. This is already happening to some extent, with food industry representatives committing to the "Agreement in Principle to Reduce Food Waste" and companies working with initiatives to reduce food waste [21]. However, this focus could be further developed to improve data quality, monitoring, and implementation of measures [30].

It should be clarified how clear responsibility for communicating the different food waste issues can be ensured. Companies should include their food waste reduction targets in their sustainability reports and raise consumer awareness [4]. At the same time, companies clearly see the responsibility for educating consumers with politicians [71]. Public authorities should continue to emphasize that everyone has a responsibility. There are differences of opinion that need to be resolved in the medium term. Otherwise, companies could use communication only for their own economic benefit. These results should be used to develop a unified communication strategy on food waste, as the minimum requirements have already been identified in Cluster 1. Even if the relevant themes have become clearer, their content and form are not fixed. Further requirements should be formulated by business organizations, policymakers, and academics to ensure the necessary transparency in line with the national strategy. This disclosure allows engagement and commitment to be monitored and evaluated. Communication on food waste is increasing, but lately almost only consumer information is published. Therefore, companies should now be reminded by public authorities to commit to being transparent about their targets and data and to support the national strategy. It is important to set a common direction to prevent food waste communication from becoming a mere marketing tool. It must be a means of support and transparency of commitment. Policymakers should support companies that demonstrate transparency in their information [91].

4.3. Practical Implementation for Companies

This paper gives an overview and inspiration for food processing companies regarding food waste communication. The results show that one out of four topics from Cluster 1 is communicated across the subsectors, namely "Business Goals". Therefore, the expansion of Cluster 1 can be the starting point for good communication for companies. Part of the expansion is the communication of "In-house Transparency", "Utilization of Remaining Materials", and "Joint Activities". In summary, companies should state what their targets are, what targets they have achieved, the figures behind the targets, what they do with the food they waste, and what joint activities they are undertaking to tackle food waste. As mentioned above, companies could focus on "Joint activities" to work with other stakeholders to save resources for communication about food waste.

In addition to the must-have topics, companies are currently most likely to communicate about "Consumer Information" and "Product and Packaging". Therefore, companies should see "Consumer Information" as a real contribution to society to address one of the most important issues of our time because communication can help improve private food management skills [9,17]. They should increase the consumer's awareness and intent to reduce food waste through financial, environmental, and food safety messages [26,69]. In this context, companies should not just publish their own opinions but also do more to

refer readers to official studies and data so that they can educate themselves. Companies should also look to their other communication channels, such as social media, for additional tips [78]. As companies communicate a lot about "Product and Packaging", they should also focus on the benefits and features of packaging to help consumers reduce food waste at home, preferably using targeted information campaigns [73] and interdisciplinary language [74].

If there is individual responsibility, food processing companies should communicate their responsibility in handling food and the problem of food waste because, in addition to food quality and food safety, the use of resources has become a mandatory program for our common future against the background of the SDGs. In general, companies should continue to communicate about food waste as part of their core business. Therefore, they should address food waste clearly, instead of ignoring it, and communicate it widely. Communication about food waste should also be framed in constructive terms to avoid negative associations [12]. Therefore, companies should take inspiration from other companies or the examples above to find their own authentic voice against food waste in their communications. However, this should not lead to the fact that advertising claims and marketing ultimately result in more food waste among consumers. In this respect, claims should be reviewed in the light of the national strategy [4]. Even when companies only supply other companies, they should still communicate about the issue. Only the entire value chain can help to solve this problem, and food processing companies can influence other actors in the chain [9]. To involve all actors in the chain and reduce the cost and time of communicating about food waste, companies can focus on the topic "Joint activities" to work with other companies or organizations. Companies can join initiatives that have already developed good messages, as many companies have already done. Coordination and collaboration are common practices [71] and critical success factors [11,12] to reduce food waste. The results are particularly relevant for small businesses when it comes to setting priorities, as they help avoid costly iterations and unnecessary efforts. Unlike large companies, small businesses often lack the same level of resources and workforce. However, their inherent flexibility enables them to implement measures more quickly [94,95]. Small businesses can especially benefit from participating in joint activities and leveraging support from organizations that already provide assistance. This approach can save both time and resources.

Nevertheless, now is a good time to communicate about food waste, as crises overlap and issues like sustainability and resource conservation become increasingly important to customers [96] and food companies [15]. These results are intended to help defuse the competition and enable joint communication. In addition, companies need to optimize their food waste content for the search engines. This will ensure that their efforts are found in the first place.

4.4. Limitations of the Study and Recommendations for Future Work

Based on the aim of the study to analyze the explicit communication on food waste, the study is limited by the choice of keywords. Therefore, it can be assumed that not every content related to food waste could be captured due to the quantity of unspecific synonyms. There are many terms that describe food waste or what could possibly be interpreted as food waste. For example, the phrase "waste" was not further differentiated by many companies, so it was not clear what the subject was. To avoid false interpretations in the data collection, only the phrases "food waste", "food losses", and "waste" in terms of raw material and products were used as search phrases. This was to ensure that packaging waste and other non-food resources would be excluded.

Data collection is reliable and valid through Google's search operators and MAXQDA Web Collector. The accuracy of the key phrases ensures validity. Furthermore, it can always

give the same results and provide the website with the keywords. This could be determined by conducting the data collection twice due to the revision and getting the same output. It is not possible to simply extend the results without repeating the entire collection process. Each time the results are extended, all the data for future research must be collected and compared with the old data. In addition, this method will not find audio, video, or image content unless it is linked to HTML text.

Furthermore, this study does not represent the entire food industry. SMEs are underrepresented. The results are limited for generalization as the sample focused on all large food processing companies. However, this study was conducted as an in-depth and exploratory study. Therefore, the sample of large companies could be only generalized to represent a group of companies committed to tackling food waste. The assumption is that the sample will have sufficient resources, worthwhile savings, and image loss due to their size. This was also the basis for the selection of the sample, as it was assumed that communicating about food waste would require significant resources and an established management structure within a company. This finding comes from an earlier survey in which companies described the implementation of measures as difficult because they require time and resources that smaller companies in particular often cannot afford [19]. However, the selection included a wide range of different companies from different subsectors. The distribution of each subsector in the selection sample was relatively homogeneous. No selection was made from the lists used; all companies were examined. The results are thus representative of large companies. Although some subsectors, such as fish, have been under-represented from the outset, these are niche sectors and should be considered separately in the future. For future research, it would be interesting to investigate how SMEs communicate on this topic and which group communicates more.

The methodological choice was limited by the deductive approach, which meant that no new categories could be developed. However, an earlier attempt to analyze online content in an indicative way did not provide the necessary subtlety to distinguish between themes. The current approach is, therefore, a theory-based analysis. The classification of the results depends on the theory used and ensures validity. Based on the preparatory work of the theory used and its anchor examples, this categorization could be done well and reliably. This shows a retest that was performed as part of updating and revising the data [41]. This involved re-classifying all the data. This made it possible to compare the results with the previous findings, and there were no deviations, except for the additions made during the update. Assignments were difficult when the addressee of the content, e.g., supplier or trade, was unclear. However, this could be determined by analyzing the context of the paragraphs with the keywords.

Furthermore, the content analysis does not show the complex meanings and narrative connections of the communicated content. To mitigate this shortcoming, examples from each category are presented in Section 3.5. However, it is not possible in this analysis to distinguish between company and subsector wording. Furthermore, the content analyses did not include images, videos, or other media. Only text-based content was analyzed. The analysis software MAXQDA proved to be very reliable because of the visual settings of the anchor examples. However, this categorization simplifies the theoretical debate about what a company should communicate.

The second content analysis, designed to provide a deeper insight into consumer communication, is limited by the same circumstances. In addition, the small sample size in this category is a limitation. Analysis proved to be a very time-consuming process due to the variety of documents, languages, word choices, contexts, and company departments.

The results of the questionnaire are limited by the small number of participants. Snowball sampling was employed to reach relevant experts via the Ministry's mailing lists.

However, this limitation is mitigated by the high level of expertise among the participants, all of whom are closely involved in the "National Strategy for the Reduction of Food Waste". The questionnaire specifically targeted experts deeply engaged with the national strategy, ensuring that respondents possessed a thorough understanding of the topic and the qualifications needed to contribute meaningfully. Participants, through their roles in their respective ministries and organizations, are recognized as highly competent and credible. This is further supported by feedback from individuals who received the questionnaire but did not participate. Non-participants cited a lack of relevant expertise as their reason for abstaining, underscoring the specialized nature of the survey. Given the niche expertise required, the results provide a solid foundation for further discussion within a forum or committee to achieve broader consensus. The clusters identified in this study serve as initial working proposals. In a subsequent step, it would be valuable to interview representatives of the food industry. This was intentionally excluded from the initial phase to avoid any potential bias toward business-specific needs.

The data used to evaluate the selection of topics was obtained in an earlier study using a questionnaire [19]. The data on effectiveness and feasibility are not verified measurements by the companies. They are the mean values of subjective self-assessment on the topics. In this context, the topics show the attitudes of the companies and the attitudes of the corporate culture of the food industry toward these topics. The data cannot be used to accurately assess whether a method is effective because it is based on self-assessment. This is also because many measures are indirect and, therefore, cannot directly reduce food waste, such as consumer information or joint activities.

Future research should explore the incentives or triggers for food processing companies to communicate more about food waste. In addition, this study was not designed to analyze the direct impact of food waste communication on consumers, as the study focuses on food waste communication in general. Therefore, the impact of online food waste communication on consumers' purchasing decisions and the impact of food waste communication on consumers' trust in brands should be explored. Furthermore, future research should examine how smaller companies can position themselves on the issue of food waste and how food waste communication could be easily integrated into a company's processes.

5. Conclusions

This study provides five priority clusters for relevant online communication on food waste for companies to support the German National Strategy for the Reduction of Food Waste. The five priority clusters were identified through a questionnaire sent to experts in the national strategy. It was checked whether companies had already implemented this communication. For this purpose, the status quo of food waste communication was identified by analyzing the websites of food processing companies and assessed using the priority clusters according to the national strategy. This study identified communication gaps and provides recommendations on how to start communicating about food waste. The results are not limited by the borders of one country because of the global challenge of food waste.

As a result, five priority clusters were identified that companies should address in turn. In Cluster 1, "must-have" topics for communication were identified, namely "Business Goals", "Business Strategy", "Process", "Consumer Information", "In-house Transparency", and "Utilization of Remaining Materials". It was found that 43.8% of the companies provide online content about food waste. Food waste is communicated online in a variety of ways, including sustainability reports, stories, interviews, websites, and other documents. However, not all topics are always communicated by all companies. It illustrates that communicating about food waste can be more complex than simply telling customers how

best to avoid waste. The most frequently communicated topics were "Business Goals", "Product and Packaging", and "Consumer Information". Companies did not necessarily communicate the measures that were well implemented in their company. Companies tend to communicate more selectively, as shown by a comparison with an earlier study. It was found that when communicating about food waste, companies communicated only two Cluster 1 topics more than 50% of the time: "Consumer Information" "Business Goals". Although companies tend to communicate Cluster 3 issues such as "Product and Packaging", the status quo shows that the choice of topics seems to be in line with the priorities of the assessment. However, the frequency of topics and the way they are communicated vary widely. The results also show that the period of the COVID-19 pandemic and the war in Ukraine led to a decline in publications on food waste. This decrease was reversed in 2023. From then on, the volume of "Consumer Information" increased more than the volume of information about the company and its goals and figures.

The results of this study will help policymakers, researchers, and companies improve the consistency and transparency of food waste communication. The findings are intended to provide an initial guide for the improvement of food waste communication in companies. In conclusion, food processing companies do not always report on food waste online. Food companies must address two key objectives in their communications: engaging with consumers and ensuring transparency about their goals, data, and waste streams. Transparency must remain a priority and be actively demanded and encouraged. Failure to do so risks a decline in the quality and availability of data.

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