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Barriers of and Possibilities for Recycling of Single-Use Take-Away Food and Beverage Packaging: Evidence from Lithuanian Market

Valdonė Daugėlaitė * and Jolita Kruopienė

Institute of Environmental Engineering, Kaunas University of Technology, LT-44249 Kaunas, Lithuania; jolita.kruopiene@ktu.lt
* Correspondence: valdone.daugelaite@ktu.edu; Tel.: +370-61595760

Abstract: The use of single-use take-away packaging for food and beverages is steadily growing globally. The consumption habits of ordering food online and the very short time of use of single-use take-away packaging suggest that high amounts of potential resources are continuously being wasted. Since there is a lack of studies that could represent the status of packaging materials used within the take-away delivery industry, it is difficult to predict the potential for material recycling and reuse. This research aimed at identifying (1) the predominant packaging materials used by the take-away food and beverage industry according to the food category, (2) packaging weight in order to understand the potential for material recovery, (3) labelling in order to understand communication with consumers about what is relevant for choosing end-of-life scenarios, and (4) the residues of the food and beverage within packaging after use, which potentially affects the recyclability of packaging. The research identified at which stages of the value chain there was a potential for the better circulation of single-use packaging materials and provided insights for decision makers (businesses, institutions, etc.) to improve the sustainability of take-away packaging.

Keywords: circular economy; take-away packaging; packaging recyclability; recycling; packaging waste; PESTEL-SWOT analysis; packaging sustainability; packaging–consumer interaction; labelling; resource efficiency

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1. Introduction

Take-away food and beverage packaging plays a crucial role in today's society. Packaging is acknowledged as a fundamental component in optimizing the efficiency and integrity of the food supply chain [1]. As the consumption of ready-to-eat foods escalates within our modern industrial civilization, food packaging emerges as a substantial segment within the packaging market, anticipated to achieve a market valuation of USD 411.3 billion by 2025 on a global scale [2].

In Europe, according to [3], the informal eating sector, which includes take-away consumption in addition to eating on premises, was valued at about EUR 130 billion in 2021, with an anticipated annual growth rate of around 6% until 2030. The same study stresses the growing popularity of take-aways: about 70% of the sector's revenues came from take-aways in 2021, up from roughly 60% in 2018. Convenience through online ordering and at-home delivery was mentioned among the driving factors of increased consumer demand.

The restaurant delivery service in Lithuania, which is a small country and has a small market in Europe, was valued at EUR 14.42 million in 2021, EUR 18.05 million in 2023, and is projected to reach EUR 28.30 million in 2028 [4]. Thus, the anticipated growth rate (6.93%) is similar and even somewhat higher compared to the average European rate. The number of restaurant delivery service users will grow from 449,000 in 2023 to 620,300 in 2028 [4].

Restaurant delivery as well as other take-away food versions require the usage of packaging. Take-away packaging ensures certain functions such as proper temperature insulation, barrier from grease and liquids, food preservation and hygiene, leakage prevention, convenience, food waste reduction, resistance to physical stress during transportation, information and warnings related to certain food and beverage characteristics (e.g., warning signs of hot content), and information of the packaging material and end-of-life (EoL) method [5]. Thus, packaging has to comply with food safety standards to ensure the quality and safety of the packaged products [6]. A wide variety of food packaging materials are utilized such as paper, metal, plastic, biobased and biodegradable materials to provide desirable functions within the packaging system for numerous types of food products [7].

However, single-use take-away packaging becomes waste after a relatively short time of use, pointing to the wasteful use of resources. Packaging materials' production and EoL treatment cause direct environmental impacts [8]. In the EU, in 2021, a total of 84 million tons, or 188.7 kg per inhabitant, of packaging waste was generated [9]. Paper and cardboard accounted for 40.3%, plastic 19.0%, glass 18.5%, wood 17.1%, and metal 4.9%. The recycling rate was 64.0% [9]. Looking into the informal eating sector, it represents about 1% of the total packaging waste in Europe [3]. The dominant materials are cardboard (56%) and paper (24%), mixed materials (13%), and plastic (17%). Only 20% of the packaging in the take-away food and beverage sector is currently recycled, while 80% is not recycled [3].

According to the Environmental Protection Agency in Lithuania, the total recycling rate of packaging was 63.8% in 2021 [10], which equals the EU average and is higher compared to only 20% of packaging waste materials recycled worldwide [11]. Country data on take-away packaging in particular are not available.

Even if the packaging is recyclable from the manufacturer's perspective, after use, when it gets dirty, it can often become unsuitable for recycling. In any case, the behaviour of the user determines where they will put the used packaging, whether they will sort it or not, and whether they will wash it first or not. At this stage, communication, information and labelling could lead to the better sorting and recovery of materials. According to [12], consumers' behaviour, habits and practices can have a significant environmental impact on the packaging during the use and EoL phases. However, local recycling facilities vary among countries and regions. Customers have to make an effort in understanding how to sort take-away packaging into proper waste streams. Packaging today has become an essential communication tool in marketing and communicating the essence and objectives of a product. Every element of a product's packaging communicates something, so the design must immediately convey the intended use and method of application [13].

Modern consumers appreciate packaging that minimizes waste, integrates recycled materials, and is recyclable once emptied. Several studies have found a positive willingness-to-pay-more mentality regarding recyclability in general and a higher willingness for the recyclability of plastic than for other packaging materials [14,15]. However, the understanding of the practical application of recyclability, biodegradability, reusability, and other environmental impact factors is limited. As a result, consumers' purchasing behaviour is often less environmentally sustainable than desired [16].

Sustainability has become one of the integral functions of packaging, in addition to ensuring food quality and safety, facilitating transportation and logistics, and enabling communication [17]. Packaging sustainability is a broadly discussed topic, and several approaches are represented by the industry. Sustainable packaging should be effective by contributing economic and social value to the product, efficient to reduce the utilization of materials and energy, circular through the optimization of material recovery, and safe by eliminating any risks related to health and ecosystems [18]. More generally, it must meet functional requirements while not overburdening the environment or causing any harm to human health through a material's lifecycle but ensuring proper material circularity [11].

A wide range of alternative packaging solutions for take-away food and beverage have been introduced globally at different levels with the purpose of eliminating non-recyclable packaging, reducing waste, or upgrading material recovery. Several reusable deposit packaging systems such as ClubZero [19], Recup [20], RingoEco [21], Recircle [22], CupCup [23], Vytal [24], DeliverZero [25], Returnr [26], Ozarka [27], etc., are being implemented as an alternative for single-use packaging formats. "Bring your own packaging" initiatives are being applied by restaurants, petrol stations, and other take-away sites to incentivize consumers to reduce packaging waste. Recycling schemes such as Simply Cups [28] and The Cup Collective [29] have been introduced in the UK, Australia, and EU aiming at collecting single-use paper cups from end users and recovering high-value paper pulp. There are some examples of edible packaging such as Biotrem and NotPla that could replace several single-use take-away packaging formats, such as sauce containers, paper–based coffee cups, and food trays.

Issues like the intensive use of take-away packaging within the catering sector, abundant waste generation in a short period of time, limited recyclability, and misleading communication with consumers, especially regarding the EoL scenario of certain packaging result in potentially greater environmental impacts that could, however, be mitigated by indicating trouble spots and applying certain measures at a sectoral level. However, evidence regarding the factual recyclability of take-away packaging is lacking. As noticed by Norton V., 2023 [30], information regarding the disposal strategies for various types of food packaging is not consistently accessible to consumers. They are seconded by Kimberly [15], arguing that although companies and policy makers are undertaking communication measures aimed at improving packaging recycling, the effectiveness of these efforts is debatable and it remains unclear how specific packaging characteristics affect recycling. There is a lack of studies that analyse the real situation of single-use take-away packaging, materials, and recyclability, and the majority represent only theoretical research studies without analysing factual packaging materials [11,12,31–34]. The current research aimed, therefore, at analysing the potential for better recycling and material circularity through gathering data from the market regarding take-away food and beverage packaging.

2. Materials and Methods

The study consists of three stages (Figure 1):

(1) The selection of food and beverages from menus and assigning them to certain categories and subcategories, with reference to the packaging requirements for each category and subcategory.

(2) An analysis of take-away packaging samples—packaging materials, sizes, weight, dirt, labelling, and potential recyclability. Packaging samples were gathered from the different restaurants on online platforms, ordering meals and beverages that were identified as the most popular meals and beverages at the first stage of the research. 10 orders per one popular meal and beverage were performed, e.g., 10 zeppelinas, 10 burgers, 10 coffees, etc. Sampling was performed to collect primary packaging samples and to register the data. Labelling was assessed from the user perspective. At the EoL stage, the waste manager identified the theoretical and practical recyclability of the collected packaging samples.
The average time of use of packaging was assessed to understand how long single-use take-away packaging performs its main function, from confirming that the order was ready to be picked up by a courier to the final delivery at the door. Packaging fees were measured, analysing what part of the business provided free-of-charge packaging, how many of businesses applied a packaging fee, and also whether the packaging fee correlates with environmental benefits (the packaging was sustainable, was from consciously sourced materials, the fee supported the company's environmental practices, etc.).

(3) The identification of key gaps and opportunities for take-away packaging circularity applying the PESTEL-SWOT matrix as a tool. This tool was selected due to the complexity of this research area, which was influenced by a number of internal and external factors. The PESTEL-SWOT matrix provided a great structure for the proper evaluation of certain influences for single-use take-away food and beverage packaging

circularity and recyclability improvement. In this part of the research, all data and information gathered from Stage 1 and Stage 2 practices were assessed and analysed, through political, economic, environmental, technological, legal, and social strengths, weaknesses, opportunities, and threats. This framework allows one to distinguish the enablers and the main obstacles to be overcome [35].

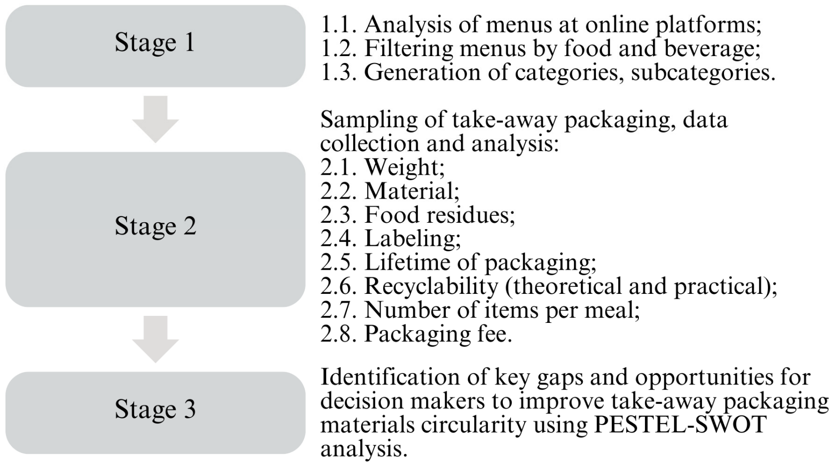


Figure 1. A scheme of research stages and analysis performed at each stage.

The scope of the research is the Lithuanian market, where three main online food order and delivery platforms take the largest market share. The study relied on these platforms, while individual businesses providing delivery service from their catering sites were not included. This methodology can be easily applied to other markets, and the study can be extended to other regions and countries.

Sample size was 270, comprising 10 orders per 27 identified most popular meals and drinks.

Categorization, packaging sampling, food residue study, and the recyclability assessment relied on several studies conducted by [36–39]; however, the overall research design was based on newly developed methodology.

2.1. Categorization of Food and Beverages Regarding Packaging Needs

The initial data collection and situation analysis was performed by gathering and comparing food menus from online food ordering and delivery platforms. This part of the research revealed what meals and beverages were the most popular within the menus of the catering businesses. Meals and beverages that were repeated at least 2 times at all three online platforms were selected for further analysis, prescribing them to categories and subcategories. Categories and subcategories were created and differentiated according to meal features, such as temperature (e.g., hot or cold), consistency (e.g., solid or liquid), moisture (e.g., dry or wet), and fatness (e.g., greasy or fatless). Foods and drinks with these certain features require diverse types of packaging. Food packaging must protect food products from outside influences and damage, contain the food, and provide consumers with ingredient and nutritional information [40,41].

2.2. Analysis of Take-Away Packaging Materials, Sizes, Weight, Dirt, Labelling and Potential Recyclability

Packaging sampling was performed by ordering food and beverages that were identified as the most popular from online platforms. Certain parameters were evaluated such as packaging materials and the active time of use of take-away packaging from the moment the order was prepared to its final delivery to the consumer. The parameters assessed through direct observation were weight, food and beverage residue level, labelling, and potential recyclability. Recyclability was assessed by experts from the waste management sector by analysing each packaging sample with food residues after their use and filling in a questionnaire, where theoretical recyclability, limiting factors, and practical recyclability (with sorting recommendations to consumers) were identified for each packaging sample.

2.2.1. Packaging Time of Use, Number of Items per Meal, and Packaging Pricing

Time of use is a crucial factor to understand the time of use of packaging. Some packaging preserves products for weeks and years, while take-away packaging has a way shorter time of use. The time of use was measured from the moment the order was prepared till the final delivery of the meal. Consumption was not considered because such meals were intended for immediate consumption, although nuances may have varied due to different consumption habits. After meals and beverages were delivered, the average number of items per order was calculated. Additional items, such as napkins, bamboo sticks, cutlery, sauce containers, primary and secondary packaging, and additional wrapping were considered. In some cases, meal can be overpackaged. Also, it was important to understand the quantity of different packaging items within the meal and beverage order—what items were unnecessary and which materials could be saved.

Packaging pricing was compared among different caterers to understand the trends, prices, and options for consumers since packaging fees applied per meal were important economic factors from the consumers' perspective. Various sources indicate that nowadays, consumers using take-away food delivery services are willing to pay more for better packaging in the context of sustainability (recyclable, reusable, biodegradable, etc.) [14,15]. The average packaging price per meal and beverage was assessed, and cutlery charges were evaluated.

2.2.2. Labelling, Packaging Materials, and Weight Identification

Single-use take-away packaging varies in size, shape, material, and labelling and might be the subject of miscommunication among different value chain parts. Labelling can influence customers on how to deal with the generated waste. Raising awareness based on scientific facts, clear product and packaging information based on labelling schemes ("eco-labelling"), and nudging towards sustainable behaviour can potentially support consumers in their sustainable buying behaviour [16]. Packaging design plays a significant role in influencing food purchases and consumer behaviour, facilitating the adoption of new consumption trends [42]. This part of the research aimed at gathering data of what type of information prevailed on the packaging and whether it was clear and easy to understand the EoL scenario of single-use take-away packaging waste. Information on the top, side, and bottom parts of the packaging was analysed, assuming that bottom labelling was less visible and made the sorting process more confusing since used packaging had to be turned over. The clarity of the labelling was assessed to understand the communication and packaging–consumer interaction. Labelling is a significant element for consumers to identify which EoL scenario is suitable for a certain packaging. Proper labelling may improve sorting, sorted packaging waste quality, and recycling rates.

2.2.3. Food Residue Level, and Recyclability

Food residue level was evaluated in each packaging sample. It helped to understand the potential of packaging material recycling, since the packaging itself could have been recyclable, but after use, it could have been comprehensively dirty and not suitable for recycling. Four food residue levels were identified: no food residues in the packaging, small food residues (some residues that had not soaked into the packaging material, mainly dry food), soaked into the packaging (usually some grease), and packaging fully or partially covered by wet food or drink residues (usually liquid from sauces, soups, stews, and drinks) (Table 1 and Figure 2).

Table 1. Levels of food residues after use within the packaging, and key features of each food residue level.

Food Residues	Features
No food residues	Packaging remains clean and unaffected by food or beverage.
Small food residues	Some food residues that can be easily removed without affecting packaging material.
Soaked into the packaging	Packaging material affected by food residues in the form of grease and cannot be removed from the packaging.
Full of wet food residues	Packaging covered by food residues in the form of grease or liquids, can be washed out by rinsing.

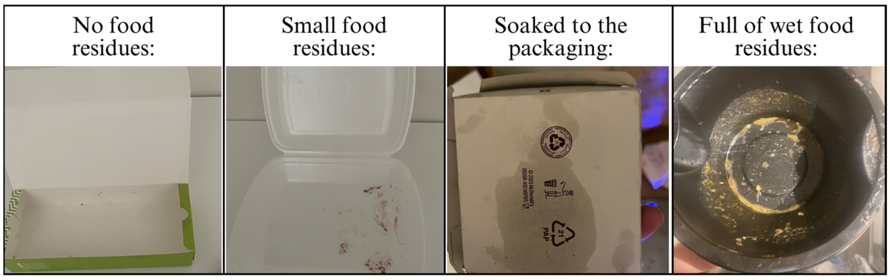


Figure 2. Examples of food residue levels within the packaging after use: no food residues, small food residues, soaked into the packaging material, full of wet food residues.

The recycling of packaging waste depends on the infrastructure the city provides [43]. The evaluation of labelling and materials will help us to understand the factual potential of material recovery from the perspective of waste recycling practitioners.

At this stage of the research, the recyclability of each packaging sample was evaluated by the waste expert studying each packaging sample along with the food residue level after its use. Questions about the recyclability of non-labelled packaging or packaging containing insufficient information with ambiguous evidence of packaging material were addressed as well. Waste recycling experts were asked questions regarding the gathered packaging samples:

1. Can the package be prescribed to a certain waste stream according to the labelling?
2. Can the package be recycled according to the material (layers, printing inks, barriers, etc.) and current recycling infrastructure?
3. Can theoretically recyclable packaging (when infrastructure is in place and materials are suitable for recycling) be recycled with the current levels of food residues?

2.3. Identification of Key Gaps and Opportunities for Take-Away Packaging Circularity

At this stage of the research, data collected from the case study was examined and key trends, gaps and opportunities were identified by applying descriptive data analysis using the PESTEL-SWOT matrix as a tool. The PESTEL framework was chosen as a strategic analysis tool for the evaluation of macro-environmental factors, such as political, economic, social, technology, environmental, and legal factors [44]. To understand the strengths, weaknesses, opportunities, and threats of political, economic, social, technology, environmental, and legal factors under PESTEL dimensions, a hybrid matrix of PESTEL-SWOT was applied. It allows one to gather imperative outcomes useful for decision makers (e.g., businesses and policy makers, such as municipalities and ministries) and enables them to redesign and promote synergies and activities to reach better single-use take-away packaging material circularity. Since the packaging industry can be seen as a complex, multidimensional system, PESTEL analysis can provide a general view of the whole situation, including an extra burden on the existing waste management system from the macro perspective [45]. According to [46], SWOT and PESTEL analysis is suitable to assess the level of environmental performance.

3. Results and Discussions

3.1. Categorization of Food and Beverages with Regard to Packaging Needs

Food menus available on online food delivery platforms were gathered and analysed, assigning food and beverages to certain categories and subcategories according to food characteristics and the needed characteristics of packaging (Tables 2 and 3).

Table 2. Categories for meals and beverages, and packaging properties required (needed) to preserve products.

Category	Meal, Drink	Packaging Properties	Meals Prescribed to Certain Category
CF	Cold food	Barrier from dirt, physical barrier	Sushi, sandwich, salads, ice cream.
HF	Hot food	Maintenance of temperature, moisture prevention	Pizza, burgers, kebabs, fish, pasta, steaks, chicken wings, woks, zeppelins, chicken fillets, tortillas, dumplings
CD	Cold drinks	Barrier from liquids, leakage insulation	Blended cocktails, fresh drinks
HD	Hot drinks	Barrier from liquids, temperature and leakage insulation	Coffee
S	Soups	Barrier from liquids, maintenance of temperature, leakage insulation	Soup, ramen, stew
G	Groceries	Barrier from dirt and other contamination sources, physical and grease barriers	Chebureki, kibin, doughnuts, waffles, pancakes

Table 3. Subcategories according to key features of food and beverage, and packaging properties that need to be met to preserve products.

Subcategory	Food Properties	Specific Characteristics	Packaging Properties	Meals and Beverages Prescribed to Certain Subcategory
1	Greasy	Has a certain level of fat	Barrier for grease	Pizza, burgers, kebabs, fish, pasta, steaks, chicken wings, woks, zeppelins, chicken fillets, tortillas, dumplings, ice cream, ramen, soup, stew, chebureki, doughnuts, waffles, pancakes
2	Wet	Usually used with sauce or wet salads	Barrier for liquids, humidity	Salad, pasta, steak, wok, zeppelin, dumpling
3	Humid (semi-wet)	No sauce used, but the meal itself has humidity	Barrier for humidity	Sushi, burger, kebab, fish, chicken wing
4	Dry	Has no humidity	Physical barrier	Sandwiches, chebureki, kibins, doughnuts, waffles, pancakes, pizza, tortillas
5	Liquid	Liquid texture	Barrier for liquids	Ice cream, blended cocktails, fresh drinks, coffee, soup, stew, ramen

Pizza, burgers, sushi, kebabs, doughnuts, sandwiches, salad, fish, pasta, steak, ramen, soup, chicken wings, woks, zeppelins, ice cream, chebureki, kibins, stews, dumplings, chicken fillets, pancakes/waffles, blended cocktails, coffee, and fresh drinks were the most popular options on the online platforms. Six categories were created according to the main features of these meals and beverages: cold food (category CF), hot food (category

HF), soups (category S), groceries (category G), hot drinks (category HD), and cold drinks (category CD). Specific functional requirements were identified for the packaging of each category (Table 2). Cold meals require prevention from dirt and other contamination sources and physical barriers, hot meals require proper temperature insulation and barriers from condensed moisture, cold drinks, and hot drinks, soups need a good liquid barrier as well as leakage insulation, and groceries need a barrier against dirt and other contamination sources, a physical barrier, a barrier from grease [5,6,40,41].

After categorizing the menu, subcategories were created to reflect potential food and beverage characteristics, such as fatness, moisture, and consistency. Five different subcategories were identified with a potential need for certain packaging properties (Table 3). The subcategories revealed what properties were the most common in food and beverages and indicated that barriers against grease, liquids, humidity, and dirt were the most relevant features needed from packaging.

3.2. Analysis of Take-Away Packaging

3.2.1. Packaging Time of Use, Number of Items per Meal, and Packaging Pricing

Single-use take-away packaging for food and beverages had an active time of use from 14 min to 33 min. The average active time of use of the take-away packaging from the delivery platform was 21 min. The time of delivery depends on several factors, such as distance from the place of order, delivery type (e.g., bicycle, car, scooter), weather conditions, and if the delivery person picks up another order on the way or not.

On average, three items per meal were counted. In total, 64% of caterers under study charged a mandatory packaging fee, which meant if the customer did not pay the packaging fee, they could not place an order. The average packaging fee per meal was EUR 0.43, and the average price per item would have been EUR 0.14 if the price of the packaging was distributed among all packaging received per order. Moreover, 36% of caterers provided tax-free packaging. Additionally, 32% of caterers provide an optional cutlery choice for the customers, with an average price of EUR 0.23 per cutlery. Coffee sellers provide differentiated packaging fees according to the volume of the beverage cup. Packaging for a small coffee (volume 200 mL) is free of charge from all vendors, and 47% of vendors serving medium-sized drinks (volume 300–355 mL) and large-sized drinks (volume 400–450 mL) apply EUR 0.45 and EUR 0.9 fees, respectively. Cold coffee is served in plastic cups, with an average packaging fee of EUR 0.4. Juices and smoothies are delivered in plastic cups and bottles for an average fee of EUR 0.4 per packaging. One vendor provides reusable plastic cups for bubble tea and smoothies, with a EUR 0.5 deposit that can be refunded at the point of sale.

3.2.2. Packaging Materials, Weight, and Labelling Identification

Material composition

Single-use take-away packaging consists of lunch boxes, disposable tableware, napkins, bags, and containers [11]. In this study, primary packaging varies among paper, plastic, and composite materials in all the identified categories CF, HF, CD, HD, S, and G. The dominant material of primary packaging within the meal categories CF, HF, S, and G was plastic, which accounted for 48%. Paper popularity for primary take-away food packaging was just slightly lower, accounting for 44%. Paper packaging is the most popular for groceries and hot foods, while plastic is the most popular for cold food and soup, and composite materials are used for cold food and hot food packaging. Composite materials like wrappings made up 8% of all primary packaging under categories CF, HF, S, and G (Table 4). In total, 72% of all orders provided secondary packaging. The dominant packaging material for secondary packaging was paper, accounting 83%, while plastic packaging accounted for 17%.

Table 4. Primary packaging materials and average weight for food categories CF (cold food), HF (hot food), S (soups), and G (groceries).

Packaging Materials for Food Categories	Paper	Composite	Plastic	Plastic Parts (Only Lids, Sauce Containers, Films)	Primary Plastic Packaging (without Lids, Sauce Containers, Films)
	(The share of each material within a food category)			(The share from the whole plastic)	
CF (cold food)	33%	17%	50%		
HF (hot food)	67%	7%	27%		
S (soup)	20%	-	80%		
G (groceries)	88%	-	12%		
Share of materials within all categories	**44%**	**8%**	**48%**	**54%**	**46%**
Average weight of primary packaging materials per meal	**19 g**	**12 g**	**13 g**	**6 g**	**16 g**

In this study, several paper packaging material types were found: PAP20-PAP22 (PAP20: corrugated cardboard; PAP21: carton, and PAP22: paper [47]), C/PAP81 (packaging made of cartons with a barrier coating (carton + plastic)), and not labelled (Table 5). Paper packaging provides perfect printing opportunities [6], is natural, has good consumer and brand acceptance, has high recycling rates due to its good recyclability, and has a widely expanded infrastructure.

Table 5. Usage of materials for primary plastic and paper packaging for food categories CF, HF, S, and G.

Packaging Material	Paper					Plastic			
Labelling	**C/PAP81**	**PAP20**	**PAP21**	**PAP22**	**Not Labelled, Insufficient**	**PP, 5**	**PS, 6**	**PET, 1**	**Not Labelled**
	100%					100%			
Distribution, %	5%	7%	16%	11%	61%	29%	17%	21%	33%
Average weight per item, g	16 g	81 g	14 g	7 g	22 g	17 g	15 g	13 g	12 g

Several types of plastics were found during the single-use take-away food packaging study, such as polypropylene (PP, 5), polyethylene terephthalate (PET, 1), and polystyrene (PS, 6) (Table 5). Plastic packaging has several advantages, such as safety, low cost, and convenience for processing, handling, and storage [48]. Polypropylene (PP, 5) is durable and can be processed through many converting methods such as injection moulding and extrusion. Its major advantage is related to the high temperature resistance which makes PP particularly suitable for hot foods and drinks, and it can be used as reusable packaging [49]. Polystyrene can be made into a foam material, called expanded polystyrene (EPS) or extruded polystyrene (XPS), which is valued for its insulating and cushioning properties [50].

Polyethylene terephthalate (PET, 1) is the third most widely used polymer, mostly for bottles, and it can be easily re-processed at high temperatures and also can be easily recycled. PET has low tolerance for heat; thus, it can be used for cold drinks and meals mostly [51]. PET has excellent transparency, a light weight, gas and water barrier properties, impact strength, UV resistance, and the inability to break [52].

Weight

The research shows that the average primary paper packaging weight per meal is 19 g, composite packaging 12 g, and plastic packaging 13 g. If one consumer per online ordering platform orders at least once per year, and the market reaches 620,300 users by 2028 [4], there is a potential to recycle 5.18 tons of paper and 3.87 tons of plastic packaging and avoid the use of 0.6 tons of composite material (Table 4). The average weight of secondary paper packaging is 24 g per order, and secondary plastic packaging weighs 4 g per meal order.

Plastic take-away packaging within food categories CF, HF, S, and G was used for liquid or wet food (soups, zeppelins, etc.). The dominant types of plastic for these categories were polypropylene (PP, no. 5) and foamed polystyrene (PS, no. 6). Plastic lids used for plastic and paper containers were made of polyethylene terephthalate (PET, no. 1) and composite plastic material. Paper was used for primary packaging in the form of bowls, boxes, and bags. The study reveals that proper labelling regarding material identification occurs on 39% of paper packaging and on 67% of plastic packaging, while insufficient labelling or unlabelled packaging accounts 61% for paper packaging and 33% for plastic packaging (Table 5).

Labelling

The labelling study reveals that most of the labelled beverage packaging has bottom labelling (89% in the CD category and 38% in the HD category). Not labelled or labelled insufficiently accounted for 56% of all orders within category HD. Each packaging shape and material has different labelling possibilities. Findings suggest that labelling, which might mislead the consumers, accounts for 53% of all primary packaging within meal categories CF, HF, S, and G (Figure 3).

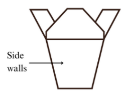
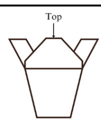
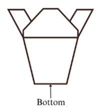
	Labelling position			**Labelling information**		
				**Labelled**	**Insufficient labelling**	**Not labelled**
Distribution, %	26%	23%	51%	47%	16%	37%
Description	All packaging labelled on side wall are made of paper, carton materials, PAP20, PAP21, PAP22	Mainly plastic container lids, sauce container lids	All types of packaging–sauce containers, food containers	Total share of labelled primary packaging	PP, 21 in triangle; triangle with arrows; brand; PEFC, food grade material.	Total share of not labelled primary packaging

Figure 3. Primary packaging labelling for all food categories CF, HF, S, and G (cold food, hot food, soup, and groceries, respectively) in the context of packaging material identification, showing labelling position (top, bottom, side wall), percentage of labelled packaging, insufficient labelling, and packaging that was not labelled at all.

Labelling was considered insufficient from the perspective of the recognizability of the packaging materials. Various self-declared environmental claims [53] provided information related to packaging sustainability (e.g., food contact material, PEFC, recyclable), and other labelling provided other information like packaging size, "contains plastic", and a triangle with arrows but did not indicate specific packaging materials. Some primary packaging consists of two separate materials—a paper-based packaging container or box and a plastic lid—but labelling appeared just on one part of the packaging, e.g., the plastic lid. Consequently, such labelling is insufficient and can lead to the wrong sorting. Another insufficient labelling example is the provision of brand and marketing information only, without any indication of the packaging materials. Some packaging had wrong labelling: paper packaging labelled PP21, which in fact should be have been labelled PAP21. Packaging labelled with the PEFC sign does not indicate the packaging material but acts as a hint that the packaging is made of paper, since the PEFC label is a globally trusted trademark helping to identify and promote materials from sustainably managed forests. Overall, insufficient labelling accounted for 16% of all packaging.

Side wall labelling appeared exclusively on paper packaging. As confirmed by [6], the use of paper as a packaging material is attributed to its good printability. Side wall labelling accounted for 26% of all packaging. Labelling on top of the packaging appeared in some formats of packaging—foldable boxes, containers (both plastic and paper), and plastic lids—accounting for 23% of all packaging.

Most often, packaging was labelled on its bottom (51%) (Figure 3).

Secondary plastic packaging was not labelled at all; 68% of paper secondary packaging had no labelling, and 32% was labelled. Regarding the labelled secondary paper packaging, 67% provided other types of information, like brand, size, and barcode, while 33% provided information about the packaging material, which was PAP22, and all of them indicated the material used on the bottom of the packaging.

Material composition and labelling of HD and CD categories

All coffee in the category of hot drinks (HD) was packed in paper-based paper cups, where C/PAP81 accounted for 31% of paper cups, PAP21 13%, and not labelled or insufficiently labelled accounted for 56%. Five main cup sizes go under this category, 200 mL, 300 mL, 355 mL, 400 mL, and 500 mL, with two types of structure (single-wall and double-wall paper cups), which determines the average weight of the paper cups. Double-wall and bigger sized cups weigh more, but as all of them belong to the same material group, the average weight was calculated combining all types and sizes of paper cups. Within the cold beverages category, 44% were served in paper-based cups (C/PAP81), 43% in PET, and 13% in PP cups (Table 6).

Table 6. Materials of primary packaging for drinks.

Category	Material	Labelling	Distribution		Average Weight per Item
CD (cold drinks)	Paper-based	C/PAP81	44%	100%	9.2 g
	Plastic	PET	43%		13.2 g
		PP	13%		21 g
HD (hot drinks)	Paper-based	C/PAP81	31%	100%	13.3 g
		PAP21	13%		
		Not or insufficiently labelled	56%		

Most of the beverage packaging for cold and hot drinks had a PS lid (50% of CD category packaging and 56% of HD category packaging), although other materials were used as well: PET (25%), biobased (PLA and C/PLA)—12%, paper-based—31%. Some lids within the category CD were not labelled at all (25%) (Table 7).

Table 7. Materials of beverage container cover (lid, cork, film).

Category	Material	Labelling	Distribution		Average Weight
CD (cold drinks)	Plastic	PET	50%	100%	4 g
		PS	25%		3.5 g
		Not labelled	25%		1.5 g
HD (hot drinks)	Paper	Paper-based	31%	100%	4.4 g
	Plastic	PS	56%		3.8 g
	Biobased	C/PLA	12%		3.5 g

3.2.3. Food Residue Level and Recyclability

Secondary packaging was mostly clean enough after use, where small food residues together with no food residues accounted for 74% of all secondary packaging. Different levels of primary packaging contamination with food residues appeared at similar frequency. Still, greasy residues in plastic packaging are the most common situation (30% of all used primary packages). Residues soaked into the material were in 19%, small food residues in 28%, and no food residues in 23% of primary packaging (Figure 4). Packaging of cold and hot drinks contains residues of different types of liquids, which has no influence on paper material due to barrier coatings in paper cups. While food preservation remains good within all meals and beverages—no spillage or leakage has been noticed.

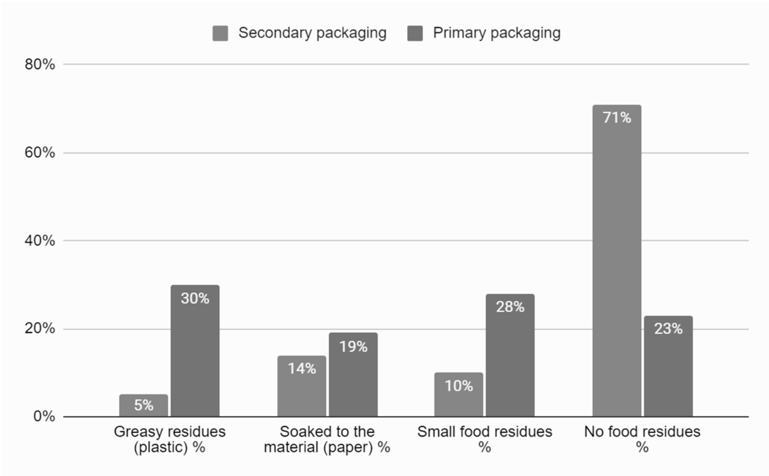


Figure 4. Abundance of food residues within primary and secondary packaging under categories CF, HF, S, and G.

The recyclability study revealed that both recyclable and not recyclable materials account for an equal share of 43%, while 14% of packaging constitutes black plastics, which theoretically can be recycled, but technically, sorting plant optics do not recognize black plastics and point them towards incineration, while manually, they can be sorted to be recycled (Table 8). Most of the paper packaging can be recycled due to relatively low levels of food residues and low grease seepage to the packaging material (59%), while non-recyclable paper packaging (41%) consists of barrier-coated, impregnated paper packaging (paper bowls, boxes, and bags for groceries). Moreover, 40% of plastic packaging can be recycled due to homogeneous materials (PP, PET, etc.), 30% of non-recyclable plastics include foamed PS with food residues, which is a limiting factor for current recycling technology, and plastic films for food container top sealing, which consists of multilayered material used to provide certain barriers, while 30% of factual plastics recycling is unclear due to the black colour as mentioned above. Composite packaging was considered non-recyclable packaging material (100%), which came from mixed wrapping for burgers, kebabs, sandwiches, etc. (Table 8).

The recyclability study showed that even if the packaging provides information on the packaging material, the product–packaging interaction (i.e., the packaging gets contaminated with food) plays a crucial role for paper and polystyrene foam packaging recycling. The recycling of plastic packaging is not limited by the food residue level; even high levels of dirt (full of wet food residues) from food and beverages allow the packaging to be recycled, except polystyrene foam (PS, 6) packaging. Plastic packaging has limitations regarding black colour because of the machinery optics. Plastic packaging made of monomaterials (e.g., PET, PP, LDPE, HDPE, PS) are well-recycled materials, but multilayered plastic cannot be recycled (Table 9).

Table 8. Recyclability of primary take-away packaging materials.

	Recyclable	Not Recyclable	Recyclable or Non-Recyclable (Depending on Situation)
Totally		**100%**	
Share of all take-away packaging materials	43%	43%	14%
Paper	59%	41%	-
Plastic	40%	30%	30%
Composite	-	100%	-

Table 9. Take-away packaging materials recycling, limiting factors for recyclability, and strategies for better recycling.

Packaging Material for Take-Away Food and Beverage	Recycling Technology	Limitations for Recycling	Strategies for Better Materials Recycling
PP black	Chemical recycling (pyrolysis, gasification), mechanical recycling	Black colour is not recognizable by sorting optics	Manual sorting, change colour, plastic pigmentation, improvement in optics
PP transparent container		Labelling is hardly visible	Improve visibility of labelling
PS foam containers	Thermal extrusion recycling	Dirt level, lots of space for transportation, low material output	Change packaging material, compressors
PS black plastic lid	Mechanical, chemical recycling	Small size may be lost in sorting drum, black colour is not recognizable by sorting optics	Change colour or add pigments, improve sorting optics, separate collection
PET containers, cups	Mechanical, chemical, biological recycling	Labelling is hardly visible	Improve visibility of labelling
PET sauce containers, lids		Small size of lids may be lost in sorting drum	Attach the lids to the packaging if material is the same
Composite plastic (sealable films)	Incineration, chemical recycling (pyrolysis)	Small size, can be lost during collection and sorting operations, cannot be recycled using mechanical recycling	Change material from composite to monomaterial, chemical recycling
C/PLA black lid	Industrial composting	Small size, can be lost during collection and sorting operations, no collection, industrial composting infrastructure, black colour is not recognizable by sorting optics	Create infrastructure for industrial composting, change to paper or plastic material, change colour
PLA black lid	Industrial composting		
C/PAP81 PAP20 PAP21 PAP22	Chemical, mechanical pulping	Barrier coating, high level of food residues, impregnated grease	Alternative coating, recycling innovations, proper packaging–product combination to improve recyclability

Impregnated paper bags for groceries cannot be recycled; labelled or unlabelled paper-based packaging with a barrier lining within the packaging cannot be recycled, even though the barrier prevents the soaking of grease and food into the material. Napkins are not considered as packaging and cannot be recycled, even if the material is paper, so the recovery of such material is not possible. Some paper-based packaging was labelled as PAP, but recyclers identified that it is covered with a barrier lining, and its recyclability is challenging. From the consumer's perspective, it is impossible to identify whether packaging contains a barrier lining or not (Table 9).

Composite packaging, which accounts for 8% among all primary packaging, had no labelling, such as burger wrapping, kebab wrapping, and grease-resistant paper sheets that are used as packaging components in barrier-free primary paper packaging (pizza boxes, sushi boxes, etc.). Plastic films used for packaging top sealing (for soups, stews, zeppelins, etc.) cannot be recycled due to the combination of materials and barriers used within the packaging material, irrespective of the food residue level (Table 9).

Biobased plastics, such as PLA or C/PLA, cannot be composted if there is no industrial composting infrastructure and separate collection, and the percentage of biobased packaging constitutes a small part compared to other packaging material streams.

Separate food waste collection is a requirement provided by the EU Waste Framework Directive. Lithuania, in response to this provision, has implemented separate food waste collection, and therefore, bamboo sticks as well as wooden cutlery (which is not packaging and so sorting it into a type of packaging is unnecessary) can be sorted into food waste streams [54].

3.3. PESTEL-SWOT Analysis

Strengths, weakness, opportunities, and threats from political, economic, social, technological, environmental, and legal perspectives are presented in PESTEL—SWOT analysis (Table 10). This was based on the scientific literature and EU legal document analysis, as well the collected evidence from the Lithuanian market. When defining strengths and weaknesses, packaging manufacturers, food and beverage suppliers who use packages, and waste management and treatment companies are considered within the value chain, while authorities/politicians, consumers, and technology developers are considered the outside actors who provide opportunities and cause threats.

Political (strengths, weakness, opportunities, and threats)

P1—Differentiated taxes for recyclable and non-recyclable packaging motivate producers to choose recyclable packaging. From 2022, producers placing recyclable packaging on the market of Lithuania have been paying lower pollution tax [55]. According to Lithuanian national laws, the packaging is considered recyclable if it is made from one material (e.g., paper, plastic, aluminium, etc.) or is labelled as homogenous packaging in accordance with the labelling system specified in the Packaging and Packaging Waste Management Rules (e.g., PAP21, PP5, PET1, etc.). If the packaging is a composite, then producers and importers, in order to classify them as recyclable, must have documents justifying that these packages meet the requirements of the specified standards and/or are recycled in Lithuania or exported to other EU countries for recycling. To classify composite packaging as recyclable, approval from accredited laboratories or from a recycler is required [56].

P2—There is still partial recycling, and the evidence of insufficient or missing labelling points to the weak incentives (legislation, financing, taxation, and political priorities). Policy makers are focusing on social issues, economic growth, and national security programs rather than waste prevention.

P3—A number of policy documents (the EU Circular Economy Action plan) and legal acts (the Single-Use Plastic Directive and Regulation on Packaging and Packaging Waste [57,58]) were adopted in recent years. Further advancement of policies and legislation is an opportunity for actors involved in the take-away packaging value chain to work on keeping materials within the economy.

P4—New legal requirements set the scene and provide opportunities for advancement in better recycling while at the same time keeping companies under some uncertainty about whether political decisions and the steps taken by companies will be in the same direction.

Table 10. SWOT-PESTEL matrix of the implementation of take-away packaging sustainability and circularity assessment.

SWOT/PESTEL	Strengths	Weakness	Opportunities	Threats
Political	**P1** Paying differentiated taxes for recyclable and non-recyclable packaging	**P2** Choosing packaging for recycling or reuse, providing clear labelling is still partial as incentives to do so are still weak	**P3** Further involvement of politicians and decision makers	**P4** Change in requirements in unexpected direction
Economic	**E1** Packaging costs fully covered by consumers. The dominant materials have economic value when recovered	**E2** Unclear correlation of packaging fee charged to consumers and environmental implications Waste treatment cost for non-recyclable packaging	**E3** Increasing market for take-away food and packaging Implementation of deposit-return systems. Consumer agreement to pay for sustainable solutions	**E4** Investments in recyclability do not pay off
Social	**S1** Good product preservation. Growing environmental awareness	**S2** Insufficient information regarding packaging materials and packaging waste sorting	**S3** Consumer awareness to pay more for sustainable packaging: more alternative packaging business models appear	**S4** Collaboration across the value chain is challenging, consumers may refuse to put effort into proper sorting and reuse
Technological	**T1** Recycling technologies for the most popular packaging materials are available Online platforms ordering system are well designed, easy to use	**T2** Technology backlashes to sort out and recycle all types of packaging materials	**T3** Innovative materials, technologies (RFID, NFC, etc.), for collection, sorting, and recycling	**T4** Technological innovations have no acceptance from businesses and consumers
Environmental	**EN1** Recyclable secondary packaging, food well preserved	**EN2** Resource loss, lots of waste in a short time	**EN3** Choice of materials and packaging design for recycling	**EN4** Packaging for recycling can have adverse effect on food that will lead to higher environmental impact. Alternative materials and recycling methods might have unexpected negative environmental impacts
Legal	**L1** Single-Use Plastic Directive (SUPD)	**L2** Biodegradable plastics are not differentiated in labelling and accounting	**L3** Upcoming Regulation on Packaging and Packaging Waste	**L4** Potential gaps in applying PPWR provisions, accounting for challenges—VAT for deposit

Economical (strengths, weakness, opportunities, and threats)

E1—From caterers' perspective, single-use packaging costs are recovered from consumers by charging extra fees for packaging and cutlery (Section 3.2.1). The dominant packaging materials are plastic and paper (Section 3.2.2), which have opportunities to be recycled into valuable secondary materials.

E2—Consumers overpay for single-use packaging via online platforms (Section 3.2.1). However, these fees do not correlate with environmental aspects; there was no information regarding the relation of fees with waste management or other aspects influenced by packaging. Consumers pay per packaging to cover caterers' packaging costs. Economic incentives for consumers' education and communication strategies to improve packaging waste sorting at the EoL stage are crucial. Since there is a lack of data about the recyclability of take-away packaging materials, it is challenging to plan investments and improve such packaging recycling. Finally, the logistics chain of recycling is complex [59]; waste management incurs potentially higher financial costs through transportation and sorting operations for non-recyclable packaging waste if packaging is not sorted properly at the EoL phase.

E3—The market for take-away food and packaging is increasing [3,4], providing opportunities to finance the search for and implementation of circular solutions.

Increasing consumers' awareness and willingness to pay for sustainable packaging [14,15] is a prerequisite to implement take-away packaging that can be recycled. Deposit-return systems are a big motivating factor for packaging recycling and reuse [60].

European funds deliver funding programs for piloting environmentally friendly technological and product innovations and plastic recycling [61].

E4—Research indicates that cooperation throughout the value chain is essential, and acquiring accurate data on the recyclability of packaging is crucial for facilitating the recovery of high-quality materials that offer economic advantages. Investments are necessary for the recycling and reuse infrastructure, packaging innovations, and consumer and caterers' education, with the risk that it may not pay off—consumers and caterers may refuse choosing reusable alternatives, innovations may be higher in price compared to the current solutions, and market acceptance might be negative. To prepare recycling instructions for consumers applying them to online platforms, the constant observation of packaging formats and updates would be necessary, which would entail additional financial costs. Any innovations require additional investments in marketing and communication to reach customers.

Social (strengths, weakness, opportunities, and threats)

S1—As this study revealed, single-use packaging performs well for product preservation; consumers obtain well-packed food without any spillage or food quality loss (Section 3.2.3). Consumers are conscious enough to choose sustainable alternatives if communication is clear [16]. Businesses are aware of consumer demand, and environmental consciousness motivates them to act.

S2—Consumers need to employ more effort to recycle packaging properly when the labelling is misleading or information about the packaging material is lacking [62]. The labelling study showed that some labels may mislead consumers (Section 3.2.2, Figure 3). In such cases, consumers are left without clear instructions on how to properly sort packaging waste. Some packaging had several different parts of material (e.g., a plastic lid and a cardboard container or a plastic lid and a plastic container), but labelling appeared on one part of the packaging only (Section 3.2.2). Moreover, sorting instructions vary among various sources (e.g., whether plastic packaging needs rinsing or not or paper packaging with soaked grease is recyclable or not), which compels consumers to avoid sorting by throwing packaging into a general waste bin.

S3—In response to growing consumer appreciation for packaging that minimizes waste [14,15], it is easier to introduce alternative packaging solutions: biodegradable, edible, recyclable, made from recycled materials, packaging with minimized weight, a variety of reuse models, and recycling initiatives [19–29]. Manufacturers may provide clear labelling and instructions indicating which products can be packed and how they can be treated after consumption (rinsed, different parts separated, etc.). Online platforms in collaboration with manufacturers may provide instructions to help caterers find several templates within the online platform and apply them to certain packaging materials they use (e.g., PAP, PP, PS, reusable, etc.) to communicate with customers in the right way. Caterers may provide alternatives (e.g., reusable packaging), as well as instructions for customers on how to treat packaging at its EoL. In collaboration with waste managers, manufacturers or licensed producers' organizations may choose the best packaging option for certain meal categories to incentivize high-quality recycling.

S4—Collaboration across the value chain is challenging [63]. There is a need for a knowledge base for choosing the right packaging for certain meal categories to meet recycling requirements. The behavioural aspect of consumers is another limiting factor since consumers may ignore information or do not recycle even if the information is represented in a clear way. Also, additional effort for proper recycling might be challenging due to the limited understanding of digital instructions [64].

Technological (strengths, weakness, opportunities, and threats)

T1—Ordering systems of online platforms are well designed, easy to use from the consumer's perspective, and provide various functionalities, for example, an optional cutlery choice, which allows consumers to refuse unnecessary items per order (Section 3.2.1). Recycling technologies are available for the most popular packaging materials (paper and plastic) referred in Section 3.2.2, Table 5.

T2—Black plastics dominate in this research (Section 3.2.3, Table 9). However, they have recycling limitations due to their sorting optics, which do not recognize black colour and directs the plastics towards incineration; only manual sorting can assure proper sorting for further recycling. To provide recycling for paper-based packaging with barrier coatings (e.g., paper cups, food containers), collection infrastructure and technological updates in paper recycling facilities are needed since the standard barrier coating applied on paper containers and cups is a limiting factor for recyclability (Section 3.2.3, Table 9). Biobased packaging (Section 3.2.2, Table 7) needs industrial composting infrastructure.

T3—Material innovations increase packaging recyclability through innovative coatings for paper packaging [65], such as black plastic pigmentation in order to improve optical sorting [66]. Technologies such as near-infrared (NIR) sensors, radio-frequency identification (RFID), near-field communication (NFC), etc., can play a significant role in improving the recycling of packaging materials by enabling better tracking, sorting, and communication throughout the packaging life cycle [67,68].

T4—Smart collection and return systems need connections with business systems, which can be challenging considering the need to ensure data interoperability and compatibility. There is the challenge of integrating technologies due to diverse technologies, systems, and stakeholders' interests and the complexity of packaging supply chain. The coordination of activities across the entire value chain—from manufacturers and retailers to consumers and recyclers—requires effective collaboration and communication mechanisms. A variety of meals and food characteristics may influence packaging food residue levels (Section 3.2.3), so a proper packaging–product combination may be a priority for factual packaging recyclability.

Environmental (strengths, weakness, opportunities, and threats)

EN1—This study reveals that secondary packaging is mainly clean and made of one material—plastic or paper—so it can be successfully recycled. Plastic packaging is well recycled if there are no additional layers within the structure. Also, plastic packaging, except polystyrene foam, can be recycled with any dirt level, and paper-based packaging can maintain a certain level of grease and remain recyclable (Section 3.2.3). Recycling infrastructure for different packaging streams (e.g., paper, plastic) is in place through the application of extended producers' responsibility, and Lithuania has a polystyrene foam (PS, 6) packaging recycling plant. Food is well preserved by proper packaging, thus preventing additional food waste.

EN2—Incorrect sorting and recycling might appear due to improper labelling (Section 3.2.2, Figure 3). Packaging waste being generated in such a short period of time (Section 3.2.1) is a significant resource loss. Greasy polystyrene foam packaging is non-recyclable and takes up a lot of space, while the output of recycled material is low. According to a recycler of polystyrene foam material, it is economically viable when larger quantities are collected, compressed, and transported for processing. Multilayered plastic packaging is technically non-recyclable. Multilayer plastic films are usually sealed on the top of food containers, sandwich boxes, etc., are transparent, and look as recyclable as monomaterial plastic, so they are challenging to identify visually. Also, the dirt level can affect the quality of recyclates, as identified by waste recyclers. So, plastic packaging covered with wet food and beverage residues is recommended to be rinsed with water after use. There is a lack of such information for consumers. Information varies in different sources, but the principal rule in sorting plastic packaging is to ensure that there is no leakage of food or drink from the packaging. In case of any food or liquid residues, consumers should ensure the packaging is clean enough. Small-sized plastic packaging such as lids, sauce containers, and cutlery (which is not packaging, theoretically, and does not need to be sorted out as packaging) is potentially not suitable for recycling. It is too small to be separated at the end of the sorting plant, falls out of the sorting drum, and is directed to incineration instead of recycling. As commented by a waste recycler, the size of items should be not smaller than 6 cm to separate them efficiently without material loss (Section 3.2.3, Table 9). Even though paper-based packaging can be widely recycled, after its contact with greasy, liquid foods that soak into the material, its recycling possibilities are compromised. Also, it can adversely affect the rest of the paper waste stream by smearing grease and food residues. This study shows that paper-based packaging can be recycled only if the level of food residues is low (no residues, small residues, low level of grease impregnation), while food residues like sauce, cream, and jam prevent recycling (Section 3.2.3, Table 9).

EN3—There are several ways to improve material circulation, such as well-designed recycling infrastructure, the application of a design-for-recycling methodology to improve take-away packaging recyclability considering certain food characteristics, potential food and beverage residue levels, and consumption models. Using certified packaging such as Recyclass [69] for plastic packaging and Papercycle [70] for paper packaging is an opportunity. The recycling of plastic packaging with a high dirt level, as well as multilayered plastics, which provide barrier properties, could be improved by chemical recycling [71], which provides high-quality recyclates corresponding to qualitative characteristics such as primary materials. Mechanical recycling is the most common plastic recycling technology and has immense potential for efficiency improvements. The rinsing and cleaning of packaging is an optional solution for better recyclability, except in cases when eating out, driving, and when there is no access to a water supply. Lightweight and efficient packaging designs could reduce the overall environmental footprint associated with packaging production and transportation [72].

EN4—Recyclable single-use packaging alternatives may have adverse effects on food preservation, which could lead to adverse environmental impacts. Chemical recycling is a promising technology for complicated plastic recycling; however, several challenges are being met, such as significant energy input, low material output, and the generation of problematic byproducts. With plastic restrictions, there is a risk of increasing the use of paper-based packaging, while paper packaging often relies on wood pulp, which can contribute to deforestation if not sourced sustainably, and other chemical processes during production [73].

Legal (strengths, weakness, opportunities, and threats)

L1—The existing uniform legal requirements, even when being strict, place companies in the take-away food value chain at an equal position. Expanded polystyrene (EPS) for food containers are restricted from being placed on the market under the Single-Use Plastic Directive (SUPD) and the requirement being implemented by the sector [58].

L2—Biodegradable plastic gets prescribed to "others". Legislation and the Lithuanian Unified Accounting Information System for Products and Packaging Waste (GPAIS) [56] do not distinguish biodegradable plastic as a unique packaging type.

L3—The upcoming Regulation on Packaging and Packaging Waste sets targets for recycling, separate collection, reuse, and waste minimization. All packaging placed on the market shall be recyclable by 2030 and be designed for material recycling, and secondary raw materials will be of sufficient quality to substitute primary raw materials. By 2035, packaging recyclability will be supplemented with additional requirements establishing that packaging waste shall be separately collected, sorted into specific waste streams without affecting the recyclability of other waste streams, and can be recycled at scale [57]. These provisions will oblige manufacturers to cooperate with other entities in the value chain to ensure that this packaging is placed on the market not only in theory but also in practice. Expanded polystyrene (EPS) for food containers is restricted from being placed on the market under the Single-Use Plastic Directive (SUPD) [58] while extruded polystyrene (XPS) packaging will be restricted under the Regulation on Packaging and Packaging Waste [57].

This study reveals that insufficient labelling may provide misleading information (Section 3.2.2, Figure 3); thus, the new packaging regulation sets new EU-wide requirements for packaging labelling. It is expected that this harmonized labelling system will provide clarity to make it easier for consumers to sort their recycling. It will be necessary to indicate what material the packaging is made of and which waste stream it belongs to. The same symbols will be used throughout the EU, labelling not only packaging but also waste collection containers [57]. Also, governmental institutions (municipalities and the Ministry of Environment) may initiate collaboration, fund studies for the identification of the main streams of take-away packaging, and set common instructions on how to recycle in collaboration with waste facilities, online platforms, and food providers.

L4—There are several potential threats regarding the application of PPWR provisions: the proper application of implementing and delegating acts and methodologies to apply design-for-recycling criteria at the level of economic operators. Freeriding packaging to the market without contributing to the costs or responsibilities associated with its production, use, or disposal is a potential threat to economies.

4. Conclusions

The study revealed that single-use take-away packaging has a great potential for recyclability and material circularity through the improvement in packaging design and labelling. Recycling and material circularity depends mainly on choices made at the packaging design stage, e.g., material, colour, packaging structure (monomaterial, multilayered), and labelling. In this study, single-use take-away packaging consisted of paper, plastic, and composite packaging materials. The recyclability of paper packaging used for take-away food and beverages is possible only with relatively low levels of food residues and fat levels soaking into packaging material, while paper packaging with barrier coatings prevents food residue soaking into the material but cannot be recycled as paper. It needs redesigning for recyclability by removing or changing barrier coatings to alternative barrier materials. Plastic packaging recyclability has limitations due to the colour of plastics (e.g., black), its composite structure, or the high dirt level in foamed polystyrene packaging. Thus, plastic packaging recyclability requires solutions for these indicated challenges through changes in colour, structural changes from multilayered to monomaterials, and finding alternatives to foamed polystyrene for greasy and wet meals. Single-use EPS packaging is already banned from being placed on the market under the SUP Directive, while XPS will be banned after the PPW Regulation is established.

Packaging labelling shows that the majority of take-away packaging needs clearer communication with consumers. Incorrect labelling was identified in more than half of the analysed primary packaging. Even in cases where the labelling itself was correct, in half of the cases, it was on the bottom of the package, making it difficult for consumers to notice such labelling. Unified labelling and visible positioning is necessary for both primary and secondary packaging to perform its communication function for better recycling and the improvement in material circularity.

Packaging performs its active function for a relatively short period of time (on average, 21 min while one meal is delivered with three packaging items). There is a potential to recycle 5.18 tons of paper and 3.87 tons of plastic packaging and avoid 0.6 tons of composite material in Lithuanian restaurant delivery market. By eliminating the current packaging recyclability issues, 2.12 tons of non-recyclable paper and 2.32 tons of non-recyclable plastic could be recycled additionally.

Packaging should be chosen based on product characteristics, and a collaboration across the value chain is needed, from packaging manufacturers, food and beverage providers, waste managers and recyclers to scientists working on material innovations and technologies. Packaging recommendations for food and beverage suppliers according to food and beverage characteristics (wet, dry, fatty, and liquid food) is of use for better material recovery. The involvement of stakeholders, including food packers, packaging manufacturers, food producers, and packaging collectors, is essential to effectively communicate with consumers through labelling that clearly indicates the appropriate waste stream for disposal. Online ordering platforms could be an additional information channel for communication with consumers to properly inform them about the recyclability of packaging. Furthermore, in sorting centres, the accuracy of the packaging waste sorting process should be improved.

However, this study has several limitations. Orders were conducted from the same venue, so the timing may be imprecise and vary with a larger scope and scale of studies. Social aspects—there was a lack of consumer behaviour understanding from different consumer groups since the evaluation of labelling was performed by the researchers. Some meals we chose were from Lithuanian national cuisine and incomparable with other markets. The life cycle assessment could be applied to compare the impacts of different packaging alternatives on the environment.

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References

1. Ada, E.; Kazancoglu, Y.; Gozacan-Chase, N.; Altin, O. Challenges for circular food packaging: Circular resources utilization. *Appl. Food Res.* **2023**, *3*, 100310. [CrossRef]
2. Wu, F.; Misra, M.; Mohanty, A.K. Challenges and new opportunities on barrier performance of biodegradable polymers for sustainable packaging. *Prog. Polym. Sci.* **2021**, *117*, 101395. [CrossRef]
3. Kearney. No Silver Bullet. Why the Right Mix of Solutions Will Achieve Circularity in Europe's Informal Eating Out (IEO) Sector. Available online: https://nosilverbullet.eu/wp-content/uploads/2023/02/No-silver-bullet%E2%80%93why-a-mix-of-solutions-is-required-to-achieve-circularity-in-Europe.pdf (accessed on 12 March 2024).
4. Statista. Restaurant Delivery—Lithuania. Available online: https://www.statista.com/outlook/dmo/online-food-delivery/meal-delivery/restaurant-delivery/lithuania (accessed on 23 March 2024).
5. Kim, Y.T.; Min, B.; Kim, K.W. General Characteristics of Packaging Materials for Food System. In *Innovations in Food Packaging*, 2nd ed.; Academic Press: San Diego, CA, USA, 2014; pp. 13–35, ISBN 9780123946010. [CrossRef]
6. Dany, H.; Utami, F.; Sulistiyono, N.; Latuheru, P.; Negeri, P.; Kreatif, M.; Pendidikan, U.; Transportasi, P.; Danau, S.; Palembang, P.; et al. Characterization Physical, Chemical, Mechanical and Optical Properties of Paper on the Market for Dry Food Packaging Applications. In Proceedings of the First Jakarta International Conference on Multidisciplinary Studies Towards Creative Industries, JICOMS 2022, Jakarta, Indonesia, 16 November 2022. [CrossRef]
7. Agarwal, A.; Shaida, B.; Rastogi, M.; Singh, N.B. Food Packaging Materials with Special Reference to Biopolymers-Properties and Applications. *Chem. Afr.* **2022**, *6*, 117–144. [CrossRef]
8. Molina-Besch, K.; Wikström, F.; Williams, H. The environmental impact of packaging in food supply chains—Does life cycle assessment of food provide the full picture? *Int. J. Life Cycle Assess.* **2019**, *24*, 37–50. [CrossRef]
9. Eurostat. Eurostat Statistics Explained: Packaging Waste Statistics. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Packaging_waste_statistics#:~:text=In%20both%202020%20and%202021,each%20following%20year%20until%202020 (accessed on 12 March 2024).
10. Environmental Protection Agency. Packaging Waste. Available online: https://aaa.lrv.lt/lt/veiklos-sritys/atliekos/atlieku-apskaita/atlieku-apskaitos-duomenys/pakuociu-atliekos/ (accessed on 12 March 2024). (In Lithuanian).
11. Zhuo, Y.; He, J.T.; Li, W.; Deng, J.; Lin, Q.L. A review on takeaway packaging waste: Types, ecological impact, and disposal route. *Environ. Pollut.* **2023**, *337*, 122518. [CrossRef]
12. Caspers, J.; Süßbauer, E.; Coroama, V.C.; Finkbeiner, M. Life Cycle Assessments of Takeaway Food and Beverage Packaging: The Role of Consumer Behavior. *Sustainability* **2023**, *15*, 4315. [CrossRef]
13. Packaging Today. Available online: https://www.packagingtoday.co.uk/features/featurecommunicating-with-consumers-through-packaging-4673481/ (accessed on 27 February 2024).

14. Klaiman, K.; Ortega, D.L.; Garnache, C. Consumer preferences and demand for packaging material and recyclability. *Resour. Conserv. Recycl.* **2016**, *115*, 1–8. [CrossRef]
15. Kimberly, K.; David, O.; Cloe, G. Perceived barriers to food packaging recycling: Evidence from a choice experiment of US consumers. *Food Control* **2016**, *73*, 291–299. [CrossRef]
16. Otto, S.; Strenger, M.; Maier-Nöth, A.; Schmid, M. Food packaging and sustainability—Consumer perception vs. correlated scientific facts: A review. *J. Clean. Prod.* **2021**, *298*, 126733. [CrossRef]
17. Boz, Z.; Korhonen, V.; Koelsch Sand, C. Consumer Considerations for the Implementation of Sustainable Packaging: A Review. *Sustainability* **2020**, *12*, 2192. [CrossRef]
18. Kozik, N. Sustainable packaging as a tool for global sustainable development. *SHS Web Conf.* **2020**, *74*, 04012. [CrossRef]
19. Clubzero. Available online: https://www.clubzero.co/ (accessed on 25 February 2024).
20. Recup. Available online: https://recup.de/ (accessed on 25 February 2024).
21. RingoEco. Available online: https://ringo.eco/ (accessed on 25 February 2024).
22. Recircle. Available online: https://www.recircle.eu/europa/ (accessed on 25 February 2024).
23. CupCup. Available online: https://cupcup.lt/ (accessed on 25 February 2024).
24. Vytal. Available online: https://en.vytal.org/ (accessed on 25 February 2024).
25. Deliverzero. Available online: https://www.deliverzero.com/ (accessed on 25 February 2024).
26. Return. Available online: https://returnr.org/ (accessed on 25 February 2024).
27. Ozarka. Available online: https://ozarka.biz/?lang=en (accessed on 25 February 2024).
28. Simply Cups. Available online: https://www.simplycups.com.au/ (accessed on 25 February 2024).
29. The Cup Collective. Available online: https://thecupcollective.eu/about.html (accessed on 25 February 2024).
30. Norton, V.; Oloyede, O.O.; Lignou, S.; Wang, Q.J.; Vásquez, G.; Alexi, N. Understanding consumers' sustainability knowledge and behaviour towards food packaging to develop tailored consumer-centric engagement campaigns: A Greece and the United Kingdom perspective. *J. Clean. Prod.* **2023**, *408*, 137169. [CrossRef]
31. Nemat, B.; Razzaghi, M.; Bolton, K.; Rousta, K. The Role of Food Packaging Design in Consumer Recycling Behavior—A Literature Review. *Sustainability* **2019**, *11*, 4350. [CrossRef]
32. Gallego Schmid, A.; Mendoza, J.M.F.; Azapagic, A. Environmental impacts of takeaway food containers. *J. Clean. Prod.* **2018**, *211*, 417–427. [CrossRef]
33. Dybka-Stępień, K.; Antolak, H.; Kmiotek, M.; Piechota, D.; Koziróg, A. Disposable Food Packaging and Serving Materials—Trends and Biodegradability. *Polymers* **2021**, *13*, 3606. [CrossRef]
34. Zeng, L.; Zhou, Y.; Zhang, H.; Cai, Y.; Yang, Z. Driving factors and their interactions of takeaway packaging waste generation in China. *Resour. Conserv. Recycl.* **2022**, *185*, 106467. [CrossRef]
35. Rim, B.; Said, M. Investigating the Viability of Implementing Electric Freight Vehicles in Morocco: Using an Integrated SWOT PESTEL Analysis in Combination with Analytic Hierarchy Process. In *Optimization and Decision-Making in the Renewable Energy Industry*; Publisher IGI Global: Hershey, PA, USA, 2022; pp. 126–152. [CrossRef]
36. Liu, G.; Agostinho, F.; Duan, H.; Song, G.; Wang, X.; Giannetti, B.F.; Santagata, R.; Casazza, M.; Lega, M. Environmental impacts characterization of packaging waste generated by urban food delivery services. A big-data analysis in Jing-Jin-Ji region (China). *Waste Manag.* **2020**, *117*, 157–169. [CrossRef]
37. Basil, F.F.A.; Tamyez, P.F.M.; Zahari, A.R.; Yao, L.; Ahmarofi, A.A. Packaging waste generation by households: A mixed method study. *Int. J. Environ. Stud.* **2023**, *80*, 964–977. [CrossRef]
38. Foodservice Packaging Institute. Food Residue Study. Available online: https://static1.squarespace.com/static/5e8221dbc8b11929c3f7eef7/t/64c125732fe366528d9d1123/1690379636000/FPI+Food+Residue+Study+2022.pdf (accessed on 24 January 2024).
39. Aarnio, T.; Hämäläinen, A. Challenges in packaging waste management in the fast food industry. *Resour. Conserv. Recycl.* **2008**, *52*, 612–621. [CrossRef]
40. Marsh, K.; Bugusu, B. Food Packaging—Roles, Materials, and Environmental Issues. *J. Food Sci.* **2007**, *72*, R39–R55. [CrossRef]
41. Guillard, V.; Gaucel, S.; Fornaciari, C.; Angellier-Coussy, H.; Buche, P.; Gontard, N. The Next Generation of Sustainable Food Packaging to Preserve Our Environment in a Circular Economy Context. *Front. Nutr.* **2018**, *5*, 121. [CrossRef]
42. Du Rietz, S.; Kremel, A. Consumer Behavior as a Challenge and Opportunity for Circular Food Packaging—A Systematic Literature Review. *Circ. Econ. Sustain.* **2023**, *4*, 413–438. [CrossRef]
43. Farooque, M.; Zhang, A.; Liu, Y. Barriers to circular food supply chains in China. *Supply Chain Manag.* **2019**, *24*, 677–696. [CrossRef]
44. Carvalho de Sousa, G.; Castañeda-Ayarza, J.A. PESTEL analysis and the macro-environmental factors that influence the development of the electric and hybrid vehicles industry in Brazil. *Case Stud. Transp. Pol.* **2022**, *10*, 686–699. [CrossRef]
45. Thakur, V. Framework for PESTEL dimensions of sustainable healthcare waste management: Learnings from COVID-19 outbreak. *J. Clean. Prod.* **2021**, *287*, 125562. [CrossRef] [PubMed]
46. Loizia, P.; Voukkali, I.; Zorpas, A.A.; Pedreño, J.N.; Chatziparaskeva, G.; Inglezakis, V.J.; Vardopoulos, I.; Doula, M. Measuring the level of environmental performance in insular areas, through key performed indicators, in the framework of waste strategy development. *Sci. Total Environ.* **2021**, *753*, 141974. [CrossRef]
47. Helsinki Region Environmental Services (HSY). Carton and Cardboard. Available online: https://www.hsy.fi/en/waste-and-recycling/waste-guide/sorting/carton-and-cardboard/ (accessed on 14 March 2024).

48. Allahvaisi, S. Polypropylene in the Industry of Food Packaging. In *Polypropylene*; Dogan, F., Ed.; IntechOpen: London, UK, 2012; pp. 3–22. [CrossRef]
49. Maddah, H.A. Polypropylene as a Promising Plastic: A Review. *Am. J. Polym. Sci.* **2016**, *6*, 1–11. [CrossRef]
50. Chemical Safety Facts. Polystyrene. Available online: https://www.chemicalsafetyfacts.org/chemicals/polystyrene/ (accessed on 14 March 2024).
51. Nisticò, R. Polyethylene terephthalate (PET) in the packaging industry. *Polym. Test.* **2020**, *90*, 106707. [CrossRef]
52. Benyathiar, P.; Kumar, P.; Carpenter, G.; Brace, J.; Mishra, D.K. Polyethylene Terephthalate (PET) Bottle-to-Bottle Recycling for the Beverage Industry: A Review. *Polymers* **2022**, *14*, 2366. [CrossRef]
53. Ecomatters. Environmental Life Cycle Assessment. Available online: https://www.ecomatters.nl/services/lca-epd/life-cycle-assessment/environmental-lca-claims/ (accessed on 23 March 2024).
54. Eur-lex. Proposal for a Directive of the European Parliament and of the Council Amending Directive 2008/98/EC on Waste COM/2023/420 Final. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52023PC0420&qid=1707729490112 (accessed on 25 March 2024).
55. VMI. Tax for Environmental Pollution. Available online: https://www.vmi.lt/evmi/mokestis-uz-aplinkos-tersima1 (accessed on 21 February 2024).
56. Lithuanian Ministry of Environment. Classification of Packaging as Recyclable/Non-Recyclable/Taxation of Non-Recyclable Packaging. Available online: https://am.lrv.lt/lt/veiklos-sritys-1/atlieku-politika/atliekos/pakuociu-priskyrimas-perdirbamoms-neperdirbamoms-neperdirbamu-pakuociu-apmokestinimas/pakuociu-priskyrimas-perdirbamoms-neperdirbamoms/ (accessed on 23 March 2024). (In Lithuanian)
57. Consilium. Proposal for a Regulation of the European Parlament and of the Council on Packaging and Packaging Waste, Amending Regulation (EU) 2019/1020 and Directive (EU) 2019/904, and Repealing Directive 94/62/EC. Available online: https://data.consilium.europa.eu/doc/document/ST-16946-2023-INIT/en/pdf (accessed on 22 January 2024).
58. Environment.ec. EU Restrictions on Certain Single-Use Plastics. Available online: https://environment.ec.europa.eu/topics/plastics/single-use-plastics/eu-restrictions-certain-single-use-plastics_en#:~:text=From%203%20July%202021,%20single,made%20of%20oxo-degradable%20plastic (accessed on 23 March 2024).
59. Cruz, N.F.; Simões, P.; Marques, R.C. Economic cost recovery in the recycling of packaging waste: The case of Portugal. *J. Clean. Prod.* **2012**, *37*, 8–18. [CrossRef]
60. Wang, C.; Zhang, X.; Sun, Q. The influence of economic incentives on residents' intention to participate in online recycling: An experimental study from China. *Resour. Conserv. Recycl.* **2021**, *169*, 105497. [CrossRef]
61. European Commission. InvestEU: EIF Invests €50 Million to Support Circular Plastics. Available online: https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4309 (accessed on 23 March 2024).
62. Oloyede, O.O.; Lignou, S. Sustainable Paper-Based Packaging: A Consumer's Perspective. *Foods* **2021**, *10*, 1035. [CrossRef] [PubMed]
63. Jäger, J.K.; Piscicelli, L. Collaborations for circular food packaging: The set-up and partner selection process. *Sustain. Prod. Consum.* **2021**, *26*, 733–740. [CrossRef]
64. Xueqing, M.; Lise, M.; Ruth, M. Switching to reuse? An exploration of consumers' perceptions and behavior towards reusable packaging systems. *Resour. Conserv. Recycl.* **2023**, *193*, 106972. [CrossRef]
65. Open Ideo. NextGen Challenge Top Ideas. Available online: https://www.openideo.com/content/nextgen-challenge-top-ideas (accessed on 23 March 2024).
66. Vibrantz. Promoting Recyclability with Near-Infrared Pigments. Available online: https://vibrantz.com/vibrantz-edge/promoting-recyclability-with-near-infrared-pigments/ (accessed on 23 March 2024).
67. Hakola, L.; Hakola, E.; Palola, S.; Tenhunen-Lunkka, A.; Lahtinen, J. Durable and sustainable smart tags for identity management and condition monitoring: Case study for reusable packaging and recyclable data carriers. *Packag. Technol. Sci.* **2024**, *37*, 107–121. [CrossRef]
68. Kroell, N.; Chen, X.; Greiff, K.; Feil, A. Optical sensors and machine learning algorithms in sensor-based material flow characterization for mechanical recycling processes: A systematic literature review. *Waste Manag.* **2022**, *149*, 259–290. [CrossRef]
69. Recyclass. Available online: https://recyclass.eu/ (accessed on 23 March 2024).
70. Paper. About Papercycle. Available online: https://paper.org.uk/Papercycle/Papercycle/About-Papercycle.aspx?hkey=0f50bb9f-4de7-4fe1-a3ce-dbd336d3d56c (accessed on 23 March 2024).
71. Circular Economy. Chemical Recycling in Circular Perspective. Available online: https://circulareconomy.europa.eu/platform/sites/default/files/2023-08/Chemical%20Recycling%20in%20Circular%20Perspective.pdf (accessed on 23 March 2024).
72. Kim, S.Y.; Kang, D.H.; Charoensri, K.; Ryu, J.R.; Shin, Y.J.; Park, H.J. Comparative Life Cycle Assessment of Reusable and Disposable Distribution Packaging for Fresh Food. *Sustainability* **2023**, *15*, 16448. [CrossRef]
73. Beckline, M.; Sun, Y.; Eric, Z.; Samuel, M. Paper Consumption and Environmental Impact in an Emerging Economy. *J. Energy Environ. Chem. Eng.* **2016**, *1*, 13–18. [CrossRef]

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