
# MASTER THESIS

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# HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES
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# FOOD WASTE IN AVIATION: THE STRATEGIES FROM THE EUROPEAN AIRLINES UNDER THE ESG AGENDA AND LEGAL FRAMEWORK

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This thesis is the fruitful result of my passion for aviation and sustainability. I believe that a greener industry is possible – and necessary – considering the changes and demands in a World in constant evolution.

I would like to thank God, my parents José Henrique and Viviane, my fiancée Danieli, my whole family and friends for the patience and support along my journey so far.

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Especially dedicated to the lovely memory of my grandmothers Norma and Celia.

# 1. INTRODUCTION

Food waste is a global issue, bringing environmental, social and economic impact to society. According to the Food and Agriculture Organization of the United Nations (hereafter FAO) (2023) it is estimated that in 2022, between 691 and 783 million people faced hunger in the world.

This sad reality is even worse when compared to the waste of food that exists. Globally, it has been estimated that around 13% of food produced is lost between harvest and retail, while approximately 17% of total global food production is wasted in households, food service, and retail combined (United Nations, n.d).

Bringing food waste to the air transport industry, the complex regulatory environment surrounding waste management poses a challenge for airlines and shipping companies operating on international routes, where regulatory inspections requires special handling and disposal procedures.

Although airline meals are prepared under strict global hygiene controls, including incineration and steam sterilization, their reuse and recycling can be challenging, if not impossible. It is worth noting that countries such as Australia, Canada, members of the European Union, New Zealand, and the United States have placed restrictions despite these measures. It is important to note that catering waste from international flights, know by the term International Catering Waste (hereafter ICW), is based on animal health concerns is a complex matter. While international arrivals into these countries represent only a fraction of total global arrivals, the tight turnaround times, lack of space in catering facilities, and the adoption of a precautionary approach are contributing factors to the issue.

Despite growing recognition of the importance of addressing food waste, empirical research on specific strategies adopted by European airlines remains limited. Existing studies primarily focus on broader sustainability practices within the aviation sector, leaving gaps in understanding the efficacy and implementation challenges of food waste reduction initiatives. So, under the Environmental, Social and Governance (hereafter ESG) and the legal frameworks, are the European airlines addressing concrete actions to tackle the food waste problem and what is the passenger behavior regarding the onboard meal service and perception of airlines sustainability?

These are questions that this thesis aims to answer, by analyzing case studies and regulatory developments, this research seeks to identify best practices, barriers, and opportunities for enhancing food waste management in the aviation sector, contributing to both academic scholarship and practical solutions for sustainable aviation.

Considering the reasonable fact that this food and drink is sealed and untouched, ans this could suggest the possibility of use — through donation, humanitarian efforts, or even – if biotreated – as a critical energy source, in fact the ICW rules effectively prevent reuse, donation, recycling and biotreatment.

The main objective of this thesis is therefore to evaluate, among the largest European airlines, their context regarding this topic of food waste generated in each flight. Another objective is to analyze the customer/passenger behavior and preferences related to food waste in aviation and airlines sustainability too.

This thesis is structured in four main parts. The first part will be devoted to an in-depth review of the existing literature on the topic. In the sequence it will be presented the methodology, clarifying the borders and approaches used. The next chapter is dedicated to results and discussions of the data gathered and considerations. The last part consists of conclusions and recommendations.

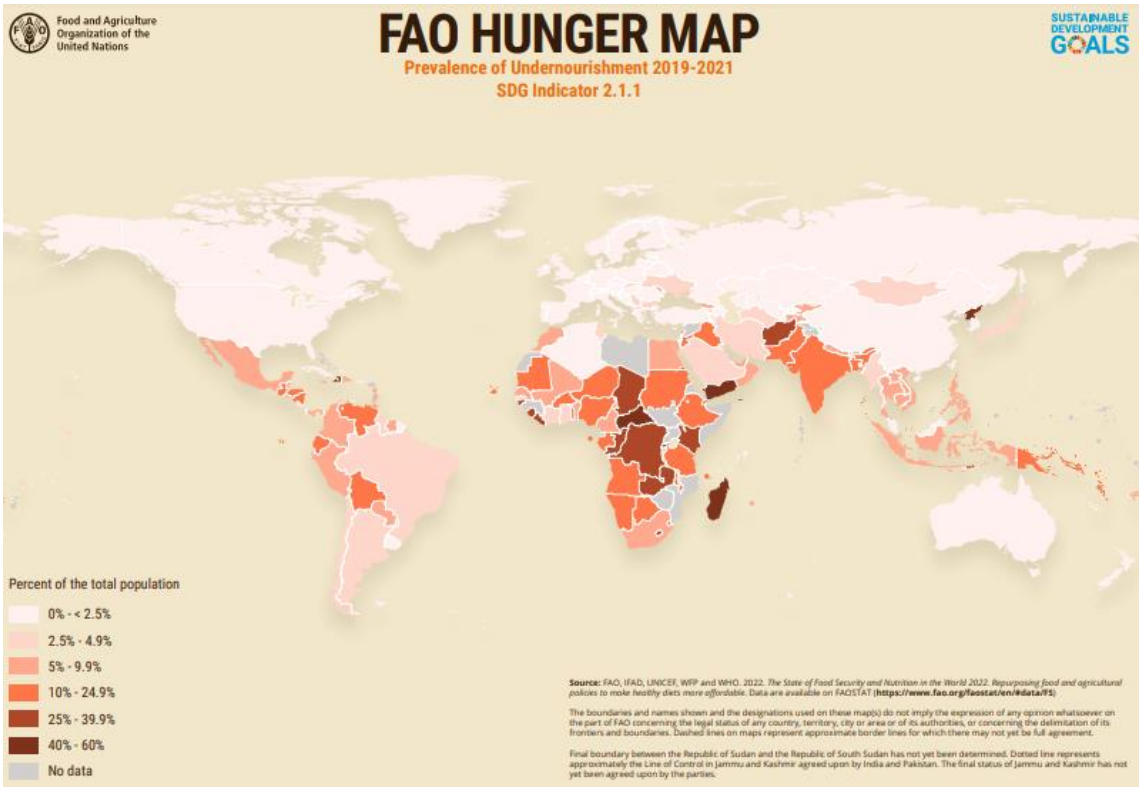
## 2. LITERATURE REVIEW

### 2.1 Hunger and food insecurity

Food waste is a hugely important global issue. It is estimated that over US$1 trillion worth of food is wasted anually (World Bank, 2020). In 2022, 2.4 billion people, accounting for 29.6% of the global population, faced moderate to severe food insecurity. Out of these, 900 million individuals, or 11.3% of the world's population, experienced severe food insecurity (FAO et al., 2023). In the Figure 1 it is possible to verify the main regions where hunger is a major issue.

**Figure 1**: Global hunger map.

*(Source: FAO, 2022)*




Food loss and waste can have an impact on the sustainability of the food systems. When food is lost or wasted, it results in a waste of all the resources that were used to produce it, including water, land, energy, labor and capital. Furthermore, the disposal of food loss and waste in landfills can lead to greenhouse gas emissions, which may

contribute to climate change. Food loss and waste can also have an impact on food security and availability and can contribute to an increase in the cost of food (United nations, n.d).

## 2.2. Sustainable Development Goals (SDGs)

In 2015, the United Nations (UN) established the Sustainable Development Goals (SDGs), a set of guidelines for achieving sustainable global development by 2030. These goals were collaboratively developed by various parts of society, including governments of UN member countries, civil society, the private sector, and educational institutions (Mazzioni et al., 2023). The SDGs, comprising 17 objectives encompassing 169 targets to accomplish by 2030 (Nishitani et al., 2021). Ending hunger is the SDG Target 2.1 and all forms of malnutrition is the SDG Target 2.2.

**Figure 2**: The 17 Sustainable Development Goals.

*(Source: UNEP and the Sustainable Development Goals, n.d)*


Considering the SDG 2 “Zero Hunger”, even though for this specific goal the target is zero hunger by 2030, it is projected that almost 600 million people will still be facing hunger until then (FAO et al, 2023).

## 2.3 Aviation catering

According to Foss (2015), it was on the morning of December 1, 1783, in Paris (France), onboard a hydrogen ballon, that the world´s first inflight beverage was drunk. The liquid was Champagne and the two men on board, the physicist Jacques Charles and his fellow Nicholas Louis-Robert were celebrating the 2 and a half hours flight, covering only 36 kilometers.

**Figure 3**: Engraving of the first hydrogen balloon flight in 1783.

*(Source: Foss, 2015)*

Giving a little context about the evolution of the meal service, cold food was the only option until 1936, when the north American company United Airlines became the first one to install a small kitchen onboard an airplane. The passengers could choose between fried chicken and scrambled eggs. As consequence, other airlines got inspired to do the same improvement. The kitchens, named galleys, were modernized, and completed with electric ovens in the beginning of the Jet Age (Compton, 2020).

Along the time, it was noticed that cooking a good meal that will be served on an airplane is different than from a restaurant, for example, because of the change in the taste. It happens due to the lower pressure of an airline cabin, consequence of pressurization, and influence the senses, where the perception of taste, and salt and sweetness, can diminish significantly. (Compton, 2020; Hayward, 2023).

To understand better this condition, the German airline Lufthansa, commissioned a study from the Fraunhofer Institute for Building Physics, in 2010, to look at the science of in-flight dining, hoping to figure out how to make its food more appealing. One of the main points is the maintenance of moisture, as it is a significant concern in the context of airline meals. In the low humidity cabin environment, the risk of dehydration is high. Food items are being developed and tested with this in mind, and modern aircraft convection ovens facilitate the maintenance of moisture (Hayward, 2023).

As aviation is a worldwide industry, the catering companies do so as well. Some of them have kitchens spread all over the world, being responsible for a huge number of meals per year. According to Pande and Karuwa (2023), the airline catering market was valued at $9.6 billion in 2022 and is expected to grow to over $20 billion by 2028.

The evolution is part of the catering industry both in the food itself but also to the other accessories related to it. A company developed a solution for economy meals, featuring a tray crafted from a blend of coffee grounds, husks, and lignin—a plant-derived binding agent. This innovative solution is part of the strategy of changing materials to reduce the use of single use plastics on board.

**Figure 4**: Redesigned economy meal using recyclable and compostable materials.
*(Source: Rueb, 2019)*

Regarding the standards for airline catering preparation, the meals served by airlines are produced using Hazard Analysis and Critical Control Points (HACCP) food safety procedures, firstly designed by NASA for the Apollo space program (Compton, 2020). The Hazard Analysis Critical Control Point (HACCP) concept represents a methodical approach to recognizing and evaluating food safety risks, along with establishing measures for their management. Serving as a managerial instrument, HACCP offers a systematic framework for overseeing identifiable hazards that directly impact food safety. This system emphasizes proactive prevention throughout the production process rather than relying solely on post-production detection of unsafe food items. By adopting HACCP, businesses streamline food processing with a focus on accuracy from the outset, minimizing the necessity for post-production monitoring, such as microbiological testing. Ultimately, HACCP stands as a cost-efficient and robust system for ensuring food safety standards.

Another document is also a reference in this industry: The World Food Safety Guidelines for Airline Catering (WFGSAC) presents an effective food safety control concept applicable to the airline industry globally and accepted as the basic reference document for all parties involved. However, in instances where national food legislation is more stringent, the WFGSAC is superseded.

## 2.4 Cabin waste in aviation

Cabin waste is the term used for all waste generated within the aircraft cabin, including cleaning, catering/galley, and items brought on board (IATA, 2019). Airline cabin waste consists of two main categories: cabin cleaning waste and catering waste from the galley (IATA, 2018).

**Cabin cleaning waste:** originates from passenger service amenities, such as newspapers, magazines, textiles (such as headrest protectors, blankets, and pillows), amenity kits, headsets, and beverage containers (both full and empty). It may also include small amounts of food inadvertently dropped or left behind by passengers, including items stored in seatback pockets. Additionally, this waste stream encompasses medical waste from used syringes, disposed of in sharps boxes, as well as waste resulting from

emergency medical care. Typically, cabin cleaning waste is collected in plastic bags and disposed of by contracted cleaning services through the airport waste management system.

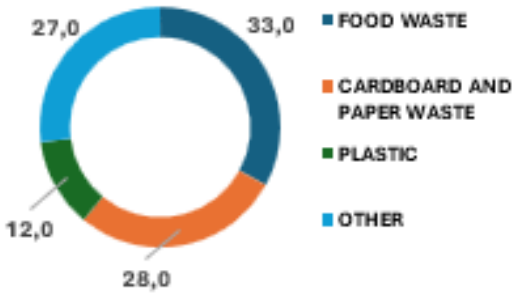
**Catering (or galley) waste**: also known as galley waste, primarily results from the provision of in-flight meals, snacks, and beverages by the crew. This waste stream includes food, beverages (both partially consumed and untouched), and associated packaging returned to the galley carts or compactors. It often contains significant amounts of liquid from unconsumed beverages and ice. Partly used alcoholic containers are securely collected in bonded carts and returned to storage facilities under customs supervision. Additionally, crew members may segregate recyclable materials such as paper, aluminum cans, and plastic bottles for separate collection. The management of galley carts falls under the responsibility of the airline catering company. Catering waste may also be disposed of in static bins or compactors and subsequently removed by cleaning contractors.

Cabin waste management in the aviation industry has garnered increasing attention due to stringent environmental regulations and the need for sustainable practices. Studies such as those by Blanca-Alcubilla et al. (2018) have emphasized the significant volume of waste generated on flights, including catering waste, packaging, and other disposable items. The amount of waste generated per passenger and flight increases on longer flights, particularly medium and long-haul flights. As a result, the total amount of waste generated increases significantly. This is due to the serving of food to economy class passengers on flights that exceed 3 hours, which is the majority of passengers (Blanca-Alcubilla et al., 2019).

Blanca-Alcubilla et al., (2019) performed a study with cabin waste from 145 airplanes and described a total of 20 different materials, the most important streams are shown in Figure 3. One of the most important focus point is the plastic, mainly the so-called single-use plastic products (SUPP), which has become a worldwide concern due to the long time for decomposition and widespread generation.

**Figure 5**: Characteristics of cabin waste (%).

*(Source: Blanca-Alcubilla et al., 2019)*




Airlines are already taking steps to minimize their contribution to plastic waste by implementing initiatives to reduce and replace SUPP, for example changing plastic packaging for paper, or plastic cutlery for bamboo cutlery. Air France, for instance, eliminated around 210 million single-use plastic items in 2019. In 2023 this initiative resulted in a replacement or elimination of 90% of SUPP for the French arline, representing 316 million items processed and 2,233 tons of plastic avoided. (More Responsible Catering, 2024).

**Figure 6**: Example of replacement of plastic for new biosourced solutions in catering cutlery and accessories.

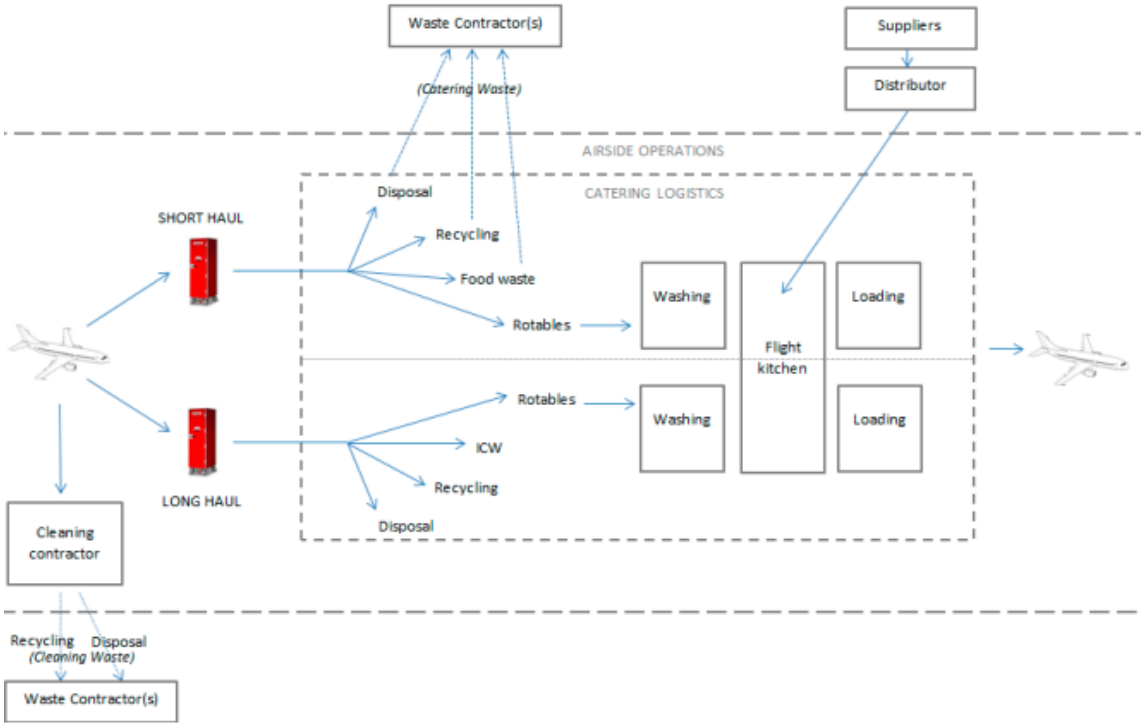
*(Source: More Responsible Catering (2024) and Reducing Waste (2024))*

Knowing in depth the composition of the different waste streams generated in the flights is one of the most important steps to reduce the cabin waste once this allows to make decisions to improve the management of this waste.

Considering the aspects of cabin waste management, it can be a complex logistics process, as can be seen in Figure 7, with different streams depending on the flight category. This differentiation explains the complex logistics process involved on the catering service in aviation.

**Figure 7**: Management of cabin waste within airside operations.

*(Source: IATA, 2023)*




The International Air Transport Association (IATA) has released a report estimating that passenger flights generate approximately six million tonnes of waste per year. Of this total, around 23 per cent is sealed food and drink, representing an estimated annual loss of US$ 4 billion (Zanatta, 2022).

## 2.5 Regulatory and legal framework

The European Union (hereafter EU) animal health regulations undermine the aviation sector's ability to make a positive contribution to the economy through initiatives to prevent, reuse and recycle cabin waste. As early as 2002, the EU introduced legislation

on animal by-products (No. 1774/2002), which classified International Catering Waste (ICW) as biohazardous waste (category 1). The current EU legislation (Regulation (EU) 1069/2009) requires ICW to be subject to strict control and treatment by incineration or disposal by deep burial in an authorized landfill (IATA, 2023).

According to Regulation 852/2004 of the EU, food waste must be disposed of in a manner that is both hygienic and environmentally sustainable, provided that there is no risk of contamination (European Parliament, 2004).

Differentiating ICW into separate categories complicates efforts to redirect food waste away from landfills or incineration, hindering potentially more advantageous treatment methods. While this approach aims to prevent risks, a consultancy group discovered that "there is no evidence that ICW from airlines has caused an animal disease outbreak, even before the enforcement of strict legislation in numerous countries," raising doubts about the effectiveness of international laws (IATA, 2018).

The designation of Category 3 waste is specifically assigned to flights operating within the EU, initially governed by national regulations that later evolved into regional legislation. Nevertheless, despite the establishment of two distinct categories (Category 1 and 3), practical implementation often results in both waste streams being treated similarly (Zero Cabin Waste, 2018).

The intricacies of Category 1 and Category 3 pose challenges for many airlines in identifying alternative disposal methods beyond landfills, given the limitations of existing domestic facilities. Ideally, Category 1 waste would undergo incineration to comply with health and safety standards, while Category 3 waste could be composted or utilized for biogas production. However, in countries like Sweden where the necessary infrastructure exists, both Category 1 and Category 3 waste often end up being incinerated, despite stringent regulations governing the handling of Category 1 waste.

Despite of these different classes, there is no scientific evidence confirming this risk and because it is too broad, similar waste must be processed in different ways, depending only their origin (KLM, 2023).

## 2.6 ESG and sustainability

Until the mid-1990s, as outlined by Clarkson (1995), corporate success was predominantly gauged by satisfying the demands of a solitary stakeholder, namely the shareholder. Yet, with evolving times and changing landscapes, notably influenced by shifts in public policies, this outlook has undergone significant alterations.

Over time, various stakeholders have begun to exert influence on corporations, prompting the incorporation of corporate sustainability into organizational strategic management. This evolution has driven companies to adopt ESG criteria in their practices (Wang et al., 2018).

The ESG criteria are being used to assess corporate sustainability and ethical performance of companies and investments (Arora & Sharma, 2022). Khalil et al. (2022) exemplifies that these parameters may encompass factors such as carbon emissions, water consumption, workforce diversity, labor standards, board composition, executive remuneration, and more. Consequently, ESG criteria furnish both quantitative and qualitative insights into a company's sustainability initiatives and their potential impact on multiple stakeholders.

## 2.7 Circular economy

Kirchherr et al. (2023), describes the circular economy as a superior alternative to the traditional linear economy, which follows a 'make, use, dispose' model. In the circular economy, resources are kept in use for as long as possible, with the aim of extracting maximum value from them while they are being used. At the end of each service life, products and materials are recovered and regenerated. This approach promotes sustainability and reduces waste, making it a highly effective solution for modern economic challenges. At the end of each service life, products and materials are recovered and regenerated.

In March 2020, the European Commission unveiled the new Circular Economy Action Plan (CEAP), a cornerstone of the European Green Deal which represents Europe’s new strategy for sustainable growth. The shift towards a circular economy under the CEAP will lessen the strain on natural resources while fostering sustainable growth

and job creation. This transition is essential for achieving the EU's climate neutrality by 2050 and for stopping biodiversity loss (Circular Economy Action Plan, n.d.) .

The updated action plan outlines initiatives that cover the full product life cycle. It focuses on product design, supports circular economy practices, promotes sustainable consumption, and aims to minimize waste and maximize the retention of resources within the EU economy for an extended period. The plan includes both legislative and non-legislative measures that address areas where EU-wide action provides substantial additional benefits.

## 3. METHODOLOGY

The methodology employed in this study seeks to investigate the intricate dynamics surrounding food waste in aviation, particularly examining the strategies adopted by European airlines within the framework of ESG agendas and legal regulations.

A pivotal component of this methodology involved the administration of a structured questionnaire to passengers, designed to glean insights into their behavior and preferences concerning inflight meals, as well as their perceptions of sustainability in the airline industry. By engaging directly with passengers, this approach aimed to capture firsthand experiences and sentiments, offering valuable perspectives on the challenges and opportunities linked to food waste reduction initiatives within the aviation sector.

The questionnaire design process entails careful consideration of key variables such as travel habits, dietary preferences, and awareness levels regarding sustainability issues. Questions were crafted to elicit nuanced responses, delving into passengers' attitudes towards inflight dining practices, their willingness to engage with sustainable food options, and their receptiveness to potential changes in airline meal offerings aimed at reducing waste.

Additionally, inquiries into passengers' perceptions of airlines' environmental responsibilities and the efficacy of existing sustainability initiatives are integral to comprehensively mapping out the landscape of sustainable practices in the aviation industry.

To ensure the validity and reliability of the data collected, the sampling techniques will be employed to select a diverse cross-section of airline passengers representing various demographics, travel frequency and flight durations. The questionnaire were distributed through multiple channels, including online platforms and mailing lists to maximize participation and reach a broad spectrum of respondents. Furthermore, appropriate measures were implemented to safeguard the confidentiality and anonymity of participants, fostering candid responses, and upholding ethical research standards throughout the data collection process.

Upon gathering the requisite data, both quantitative and qualitative analyses will be conducted to discern patterns, trends, and correlations within the dataset. The findings

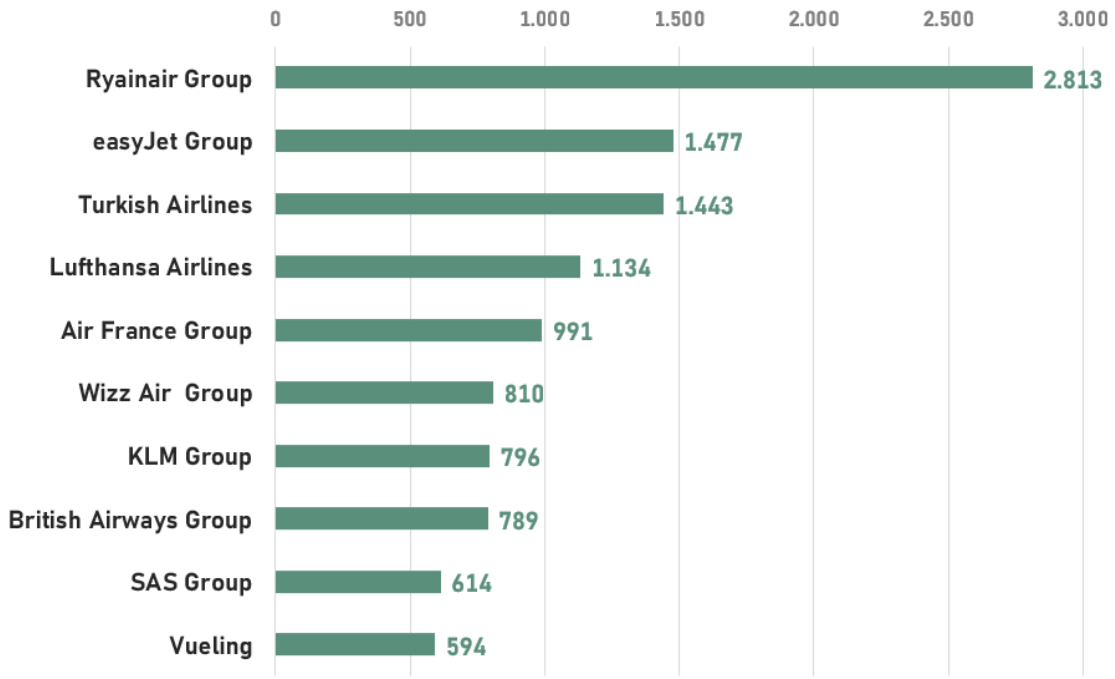
derived from this comprehensive analysis will form the foundation for evaluating the effectiveness of current sustainability strategies employed by European airlines and proposing actionable recommendations for enhancing food waste reduction efforts within the context of broader ESG and regulatory frameworks.

For the delimitation of the research, the sustainability reports from the 10 main European airlines were evaluated, searching for information on their approach and initiatives regarding the food waste issue.

The airlines list was determined according to the average daily flights in 2023, using data provided by Eurocontrol, the European Organization for the Safety of Air Navigation, as seen on Figure 8.

**Figure 8**: The 10 leading airlines in 2023 based on average daily flights in Europe.

*(Source: Own editing based on Eurocontrol, 2024)*




The survey instrument was a structured questionnaire (Annex) developed based on a review of relevant literature and preliminary interviews with frequent flyers and experts in airline catering services.

Data collection was conducted over a period of one week. The survey was distributed electronically via email and social media groups to a database of passengers who agreed to participate in airline-related studies, gathered from collaborating airline partners. Reminder emails were sent to maximize the response rate and ensure the maximum replies as possible.

This study was conducted in accordance with the ethical guidelines of Hungarian University of Agriculture and Life Sciences Research Ethics Committee. In the introductory text it was informed that the participation of every person would be anonymous and confidential. Participants were informed of the purpose of the research, and voluntary participation was emphasized.

This methodology provides a comprehensive framework to systematically explore and understand the behaviors and preferences of airline passengers concerning inflight meals and sustainability, ensuring robustness and reliability in the findings. The methodology considered if the food waste topic is mentioned in the sustainability report and what is the strategy to tackle this issue.

## 4. RESULTS AND DISCUSSION

### 4.1 Findings from the sustainability reports

The Table 1 reveals the findings of the latest sustainability report from the 10 major European airlines, based on the average daily flights in 2023. Airline sustainability reporting remains as an underexamined area in scholarly research (Zięba & Johansson, 2022), however it is being increasingly more frequent to the airlines to release sustainability reports, under the ESG requirements for most part of the economic segments.

The reports were assessed carefully and completely, looking for the terms food, meals, catering and waste and any mentions about actions or plans to tackle food waste.

**Table 1:** Airlines and actions related to food waste in the sustainability reports.

*(Source: Own work)*

| # | Airline | Country | Year | Mention about food waste in latest Sustainability Report |
|---|---|---|---|---|
| **1** | *** Ryanair Group** | Ireland | 2023 | No |
| **2** | *** Easyjet Group** | United Kingdom | 2022 | Yes |
| **3** | **Turkish Airlines** | Turkey | 2022 | No |
| **4** | **Lufthansa Airlines** | Germany | 2023 | Yes |
| **5** | **Air France Group [1]** | France | 2022 | Yes |
| **6** | *** Wizz Air Group** | Hungary | 2022 | No |
| **7** | **KLM Group [1]** | Netherlands | 2023 | Yes |
| **8** | **British Airways Group [2]** | United Kingdom | 2023 | Yes |
| **9** | **SAS Group** | Sweden | 2022 | No |
| **10** | *** Vueling [2]** | Spain | 2022 | No |

[1] Members of Air France KLM Group.
[2] Members of IAG Group.
* Low-cost carriers

## 4.2 Strategies

### 4.2.1 Previous food choice

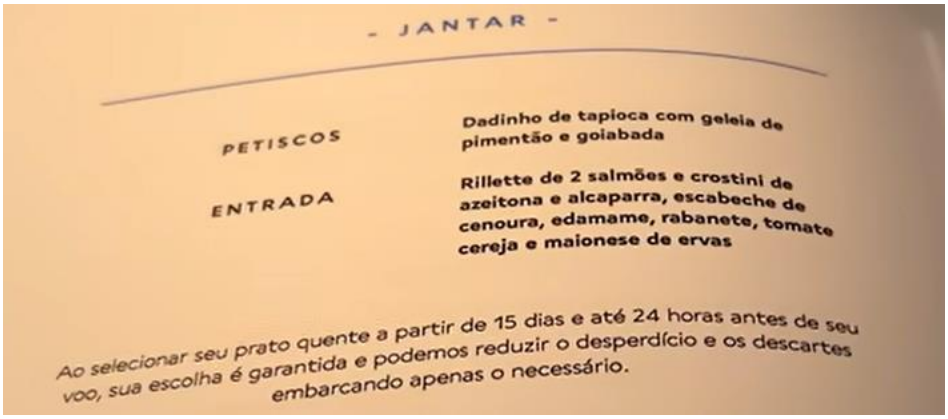
One of the strategies used is to allow to the passenger the possibility of choosing their meal days before the flight. Passengers flying in the long-haul Business cabin of Air France, for instance, have the option to pre-select their meals ahead of their flight, ensuring their preferred choice is available. This practice allowed the French airline to board only the meals that will be consumed, thereby reducing onboard weight and consequently lowering also fuel consumption. In 2023, this initiative helped to avoid boarding over 52,000 hot meals (More responsible catering, 2024).

The Spanish airline Iberia, offers a "BuyBefore-You-Fly*"* service on short haul flights and British Airways, both members of IAG Group, offers a pre-ordering service for products from the on-board "SpeedBird Café", to give passengers the choice of buying fresh and ambient products before departure. These services remove food waste from unpurchased short haul economy cabin meals while maintaining customer choice.

In the Figure 9 it is possible to see the menu of a business class service menu in an Air France flight, in Portuguese, highlighting the fact that by selecting the hot dish from 15 days and up to 24 hours before the flight, the choice is guaranteed and they can reduce waste and discards by loading only what is necessary.

**Figure 9**: Previous food choice message in an Air France flight service menu.

*(Source: Carioca NoMundo, 2024)*



This possibility is also used by other airlines in the World. The Dubai flag carrier Emirates introduced in 2023 a pioneering meal preordering program, empowering travelers to select their preferred hot main meal between 14 days and 24 hours prior to departure, enhancing onboard dining and minimizing food waste.

Initially offered in Business Class on Dubai-London flights, passengers can peruse and pick from a variety of regionally inspired dishes via the Emirates website or smartphone app, with the option for special meal requests. Cabin crew will employ a tailored app to deliver passengers their selected meal during the flight. Emirates aims to broaden this initiative across more routes and cabin classes, guided by customer feedback (Emirates, 2024).

### 4.2.2 Skip inflight meal

Despite no European airline clearly uses this approach, the skip inflight meal is a reality for some airlines in other regions. Starting from December 2020, the Asiatic Japan Airlines (hereafter JAL) on the Haneda-Bangkok route and subsequently expanded to all its routes, JAL introduces a meal omission option. Selecting this option means passengers forego the main meal service, with JAL instead contributing the meal cost to "Table For Two", an organization dedicated to providing lunches for children in developing nations.

The American Delta Airlines also offers this possibility flying in business class. According to Marcus (2023), since the program started, in 2022, around 1,000 and 1,500 meals are declined voluntarily every month.

This solution could be interesting considering that is roughly similar to the previous food choice, but with a '*no*' as reply. Nevertheless, it seems feasible only for short haul routes.

### 4.2.3 Artificial intelligence

The use of technology and more specifically, artificial intelligence (hereafter AI) is increasing in the catering area. The Dutch airline KLM has utilized AI to develop a solution to face the food waste. Through AI algorithms, the company can make highly

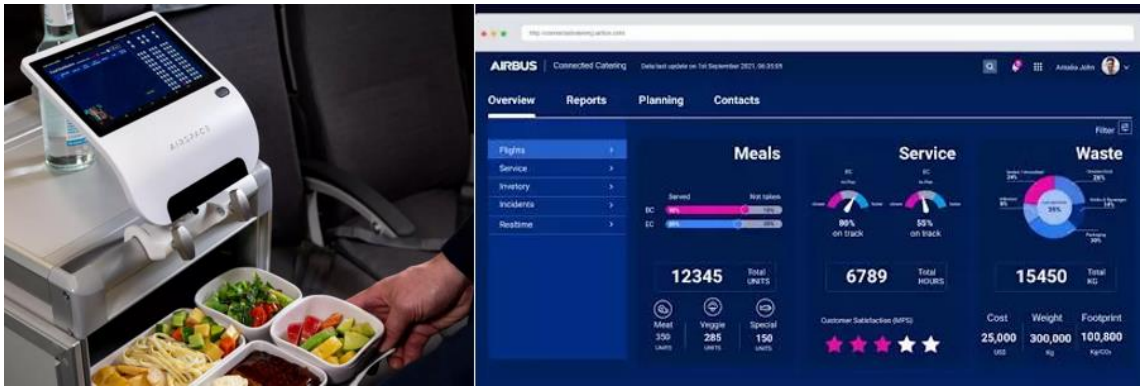
accurate predictions regarding the number of booked passengers expected to board each flight. As a result, this capability enables precise calculations of meal requirements, resulting in a reduction of up to 63% in food waste based on anticipated passenger numbers per flight. The system used uses historical data to forecast the number of passengers on board. That number is then entered into the "Meals on Board System" (MOBS) on a flight-by-flight basis.

This forecasting process starts 17 days before the flight and continues until 20 minutes before the airplane take off. The AI is being employed to help determine the number of meals that need to be loaded for any flight, based on the fact that not everyone who has booked actually end up flying. This would represent a saving of more than 100 tonnes of meals per year (KLM, 2024).

It is not only airlines who are developing solutions based on AI to tackle food waste in the industry. The European aircraft manufacturer Airbus developed an AI based solution to track the in-flight catering, named "Food Scanner" (Figure 10).

**Figure 10**: AI based solution developed by Airbus.

*(Source: Airbus, 2022)*




The "Food Scanner" is an AI-powered device that quickly and accurately analyses the composition of food. It uses the same technology as scanners that are becoming increasingly common in supermarkets. The camera attached to the trolley identifies what is on the meal tray as the cabin attendant pulls it out. It also captures images of what remains when the tray is returned. The horizontally oriented barcode scanner tracks the

beverage cans and bottles that are typically placed on the trolley. A cloud-hosted dashboard (Figure 10) shows trends and statistics for catering prediction and planning to minimize waste (Airbus, 2022).

The Asiatic China Eastern Airlines uses data systems to make its food production facility in Shanghai more efficient. The carrier's catering team can access real-time flight and seat change information to make last-minute changes to the amount of food produced and sent to different aircraft (Surette, 2023).

This possibility in the China Eastern Airlines is interesting due to the fact that the meals can be sent to other aircraft, so the meal would keep the necessary conditions for safe consumption while the most correct amount of food is sent to each flight.

### 4.2.4 The pressure of airlines on legislation changes

From the legal perspective, the food waste in aviation faces a huge challenge. Due to the critical role of biosecurity at borders, countries have the authority to govern the disposal of food waste upon landing, presenting obstacles to recycling initiatives.

Australia, Canada, European Union countries, New Zealand and the US have some of the strictest laws. But an IATA-commissioned study indicated that in fact, the actual risk is minimal (Walker, 2020). Considering the different animal health status among the countries, one possibility would be to establish a risk matrix, allowing the possibility of reuse or donation of untouched food in flights between countries with low risks associated. For countries with higher risks, for meat but not for vegetables, the meat could be disposed of however the vegetables could have another destination.

One example of how limitant the legislation can be, is that a coffee cup from the US will be classified as hazardous waste due to the potential presence of milk (Boyd, 2018). The ambition seen in the sector is to develop smarter regulations which maintain animal health controls and guarantee food safety whilst facilitating the circular economy. Some of the airlines, like KLM, use the social media to highlight the importance of a legislation change (Figure 11).

**Figure 11**: KLM post on LinkedIn about food waste.

*(Source: KLM, 2023b)*


The example of the post on LinkedIn is part of the strategy of showing the efforts from airlines regarding the destination of the food waste and put pressure on policymakers to promote the change on regulations in Europe. At the same time to gain the public sympathy to this cause.

IATA and the United Nations Environment Programme (UNEP) in fact have entered a Memorandum of Understanding (MoU) that aligns with the UN 2030 Agenda for Sustainable Development, aiming to tackle sustainability challenges within the aviation industry and turn easier the implementation of solutions. IATA is calling for a simplified and harmonized regulatory environment that will reduce the use of plastics, encourage reuse, and facilitate recycling of cabin waste, including plastics, where needed (Gavine, 2018).

Exemplifying some of the incongruencies of the legislation, for KLM airline, the coffee ground from European flights is turned into compost and biogas, meanwhile the same coffee ground from intercontinental flights, arriving in Schiphol airport – which serves the Dutch capital – are burnt with other waste (KLM, 2023a).

Regarding the Lufthansa Group sustainability report, related to year 2023, the German airline informed the adoption of a "to go" scheme, where fresh products left over on the final flights of the day are offered to the passengers for sale at reduced prices. Lufthansa, Swiss and Austrian Airlines, both owned by the German group, now offer customers the opportunity to make advance orders on short haul flights in Economy Class and pre-select products in Business and First Class on long-haul flights as well.

Reducing food waste is an opportunity to reduce costs too – as per IATA (2023), the expenses can range from US$125/tonne at Amsterdam Schiphol Airport (AMS) to US$500/tonne at Hartsfield-Jackson Atlanta International Airport (ATL) – and to tackle some of the biggest environmental and social issues of this generation: fighting climate change and addressing food insecurity. (UNEP, 2024).

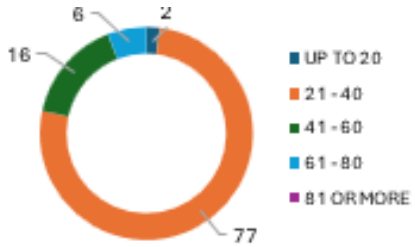
## 4.3 The passengers opinion

In parallel to the analysis of the sustainability reports, research through a questionnaire prepared with questions focused on customer behavior regarding inflight meals had in total 153 filling up the survey.

The first question, related to age group (Figure 11) reveals that 77% of the interviewee are between 21 and 40 years old, which is relatively a young predominancy.

**Figure 12**: Age group (%).

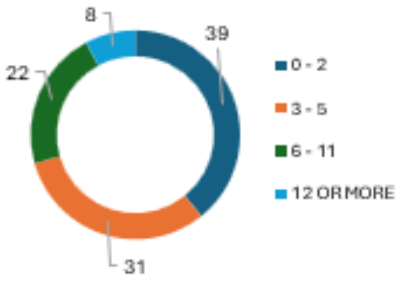
*(Source: Own work)*



When considering the frequency of flights (Figure 12), 70% fly up to 5 times a year, with 39% flying up to twice a year and 31% flight from 3 to 5 times annually.

**Figure 132**: How frequently do they fly in commercial aviation annually (%).

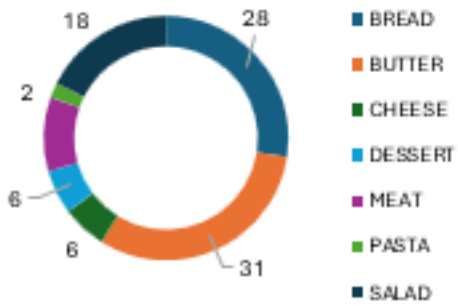
*(Source: Own work)*




Regarding the type of leftover food during the flight (Figure 13), 31% chose the butter and 28% chose the bread, with 18% stating that the most common to leave in the tray is the salad. These data can suggest that airlines should eventually evaluate the reduction of the portion for these items (they represent 77% of total), or deeper analysis on why this happens, like the influence of taste for instance.

**Figure 143**: What is the most common leftover food (%).

*(Source: Own work)*

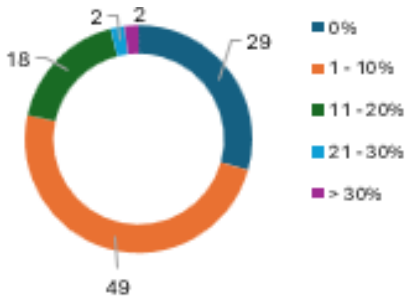



The most part of passengers who replied the survey informed that they leave some food on the tray (Figure 14), but the amount for almost half of them (49%) is below 10% of the food served. For 29% the leftover food is zero, meanwhile for nearly one quarter the amount is from 11 to 20%. In combination with the most common leftover food, this

data can support some initiative in the industry to reduce the amount of food waste understanding deeper the reasons behind it.

**Figure 154**: How much of the food is leftover (%).

*(Source: Own work)*

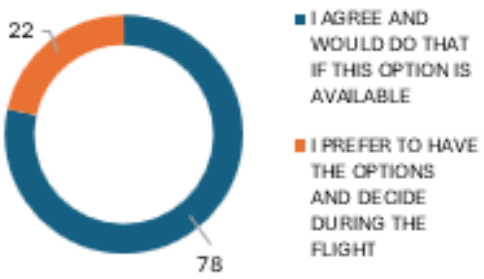



The result of acceptance of pre-choosing the meal (Figure 15) is quite important, with 78% of the passengers in favor of this initiative. This could be an important driver for airlines interested in reducing the on-board meals, for example. For those airlines that already use this tool, this option could be highlighted, as Air France already does (Figure 9) in their menu.

In fact, this solution is not so challenging to the industry and apparently can solve both problems, with the passengers selecting exactly what they want, and in parallel the airlines would load only the necessary amount of food, reducing the cost from catering service and at the same time, with a lighter weight, promote a better fuel consumption in the flight.

**Figure 165**: Acceptance of pre-ordering the meal (%).

*(Source: Own work)*



So relevant as the amount of people who are open to previously choose the meal, is that passengers also are open to refuse the meal too, if they want. For 65% of the interviewee (Figure 16), refuse the meal served was already done for some reason, like short distance flight or not hungry at that moment, for instance. For 72% of passengers, in flights with duration is below than 3 hours, free meals would not be necessary. This could lead to cheaper tickets and more satisfaction fro the passengers as they could spend the money with a more sophisticated meal in a restaurant in their destination.

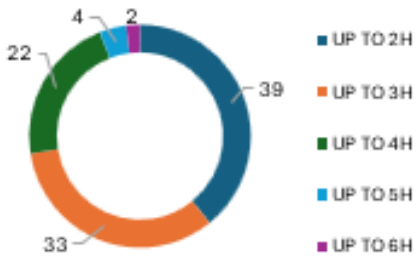
The option of previously refusing the meal, as already being used by JAL and Delta Airlines for instance, in a certain way is positive for the rising number of more conscious passengers, that would feel relieved by the fact that this food would not be wasted. With the increasing awareness of social and environmental consequences of daily actions, if the passenger has the power of deciding one thing that would avoid a known impact, more airlines could offer this possibility in the market.

**Figure 176**: About refusing meal onboard (%).

*(Source: Own work)*


**Figure 187**: How long would you accept remain without free meal in a flight (%).

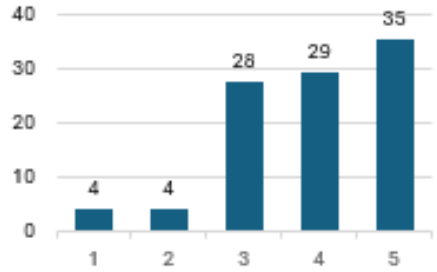
*(Source: Own work)*



As can be seen in Figure 18, the passengers consider the meal served onboard a relevant factor for the overall satisfaction during a flight, this way the airlines could know that they must invest in the experience onboard, as well as focusing in the sustainability aspects of the service.

**Figure 198**: Importance of food for the overall satisfaction in a flight (%).

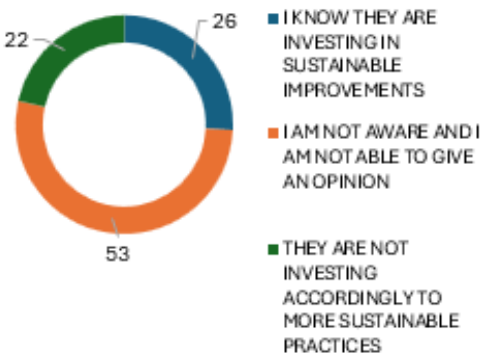
*(Source: Own work)*




An important output from the survey was that half of the passengers (Figure 19) are not aware of the airline's commitments to sustainability, which means that the communication process could be better developed and addressed to customers in a more efficient way. For one quarter of the customers, they know that airlines are investing in sustainable improvements, however for 22% the perception is that they are not investing properly in sustainability.

**Figure 20**: Perception of airlines commitments to sustainability (%).

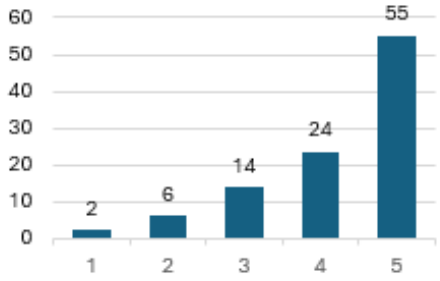
*(Source: Own work)*



For 79% of the passengers (Figure 20), sustainability is considered important when flying in a more sustainable airline, with score 4 and 5 in the scale of 1 to 5, where 1 is not important and 5 is very important. This result reveals that the topic of sustainability really must be addressed by the airlines, serving as additional pressure for improvements and for a clear communication to the market and customers.

**Figure 210**: Importance of sustainability when choosing an airline (%).

*(Source: Own work)*



## 5. CONCLUSIONS AND SUGGESTIONS

The current research aimed to identify the legal framework and the main strategies adopted by the main European airlines to tackle the food waste issue in aviation, besides identifying the passenger behavior and preferences regarding inflight meal and the perception of airlines sustainability.

This research has shown that the food waste issue is present in the agenda of the main European airlines, especially the ones operating long haul routes, with the use of innovation, like the use of AI, for instance, or giving the option of choosing previously the meals. However, in general this case it is currently limited for business class tickets, which represents a minor fraction of the seats.

The airlines which operate in the low cost model are not developing specific actions regarding the food waste from the flights. Two reasons can explain this behavior. The fleet from these airlines (i.e Ryanair, Wizz Air) are narrowbodies, smaller aircrafts for short haul routes. Secondly, following the market practice for this business model (ULCC), they only have snacks for sale on board. If it is not sold in a flight, usually can be sold in the following flights, since the storage conditions are respected. This way, as the amount of food and beverage is limited and with minimum impact, the food waste is not properly a big issue that they can consider prioritizing. In the other hand, it must be recognized that even ULCC have been adopted changes to reduce the amount of SUP onboard.

If the regulation were to be revised, it could pave the way for airlines to increase their contributions of food to communities in need. Any food considered unsuitable for donation could subsequently undergo composting or be converted into biogas.

The airlines face criticism for not contributing to the circular economy, however this is based on restrictions introduced over two decades ago. However, existing regulations reduce the ability to build a circular economy and contribute to the United Nations' Sustainable Development Goals (SDGs) target to cut global food waste in half by 2030. Airlines seems to work in a proactive way with regulators to ensure that aviation makes a positive contribution to this SDG target.

As suggestions to the industry, the catering companies, as mentioned by Megodawickrama (2018), in association with the airlines should adapt their strategies for handling excess food orders and production. One effective approach could involve enhancing standardization across customer menus, particularly for economy meals, which constitute the bulk of production. Greater menu standardization would offer increased flexibility in utilizing surplus food, thereby reducing waste.

Regarding the limitations of this research, it could be evaluated in the future the establishment of metrics for food waste per airline, for instance and a deeper consultation with the airline's association, as this is a topic with increasing interest from the stakeholders. Also, could be performed a risk assessment of the leftover and untouched food of flights from different countries, as it could support with clear scientific evidence the regulation changes.

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**ANEXX**

**Questionnaire**

**1. What is your age group?**
0 – 20 | 21 – 40 | 61 – 80 | > 80

**2. Which continent are you from?**
Africa | Asia | Central America | Europe | Middle East | North America | Oceania | South America

**3. How many times per year do you use to fly in a commercial flight (in average)?**
0 – 2 | 3 – 5 | 6 – 11 | 12 Or more

**4. What type of food is it most common for you to not to eat completely during a meal offered on a flight?**
Bread | Butter | Cheed | Dessert | Meat | Pasta | Salad

**5. Of the meal you are served on board the plane, approximately how many % of the food and drink are left on your tray at the end?**
0 | 1 – 10 | 11 – 20 | 31 – 40 | > 40

**6. How do you consider the idea of choosing previously (like 2 days before the flight) the meal you will have on board?**
I agree and would do that if this option is available | I preferer to have the options and decide during the flight

**7. Did you already refused the meal served on board a flight (due to short distance flight, not hungry, price, etc.)?**
Yes | No

**8. How many hours would you accept remain without a free meal offered by the airline during a flight?**
Up to 2 h | Up to 3 h | Up to 4 h | Up to 5 h | Up to 6 h

**9. In a scale from 1 to 5, how important is to you the meal served on board for your overall satisfaction of a flight?**
1 | 2 | 3 | 4 | 5

**10. How do you see the airlines commitments to more sustainable practices?**
I know they are investing in sustainable improvements | I am not aware and I am not able to give an opinion | Thet are not investing accordingly to more sustainable practices

**11. In a scale from 1 to 5, how important is to you flying in a more sustainable airline?**
1 | 2 | 3 | 4 | 5

**DECLARATION**

**the public access and authenticity of the thesis**

| | |
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| Student's Neptun code: | BSZEBS |
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| Year of publication: | 2024 |
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Gödöllő, 2024 April 29

Raphael S. Bail

Student's signature

**DECLARATION**

Raphael Schumacher Bail (NEPTUN code: BSZEBS) as a consultant, I declare that I have reviewed the thesis and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

**I recommend** the thesis to be defended in the final examination.

The thesis contains a state or official secret: yes **no**

Date: Gödöllő, 26.04.2024.

insider consultant