

Risk-Benefit Analysis of Circular Economy Practices in Dutch Institutional School Catering

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Executive Summary

Food waste is a significant global issue with economic, social, and environmental implications. The catering sector, particularly institutional catering in settings such as schools, contributes considerably to this problem. Alongside the increasing prominence of the circular economy, principles highlight the need to decrease food waste, calling for circular catering practices throughout the supply chain.

This research aims to gain an in-depth understanding of the risks and benefits associated with implementing pre-consumer circular catering practices in the Dutch school catering sector aimed at decreasing food waste. Circular catering practices were analysed based on their level of circularity in a food waste hierarchy along with their associated economic, social, and environmental benefits and risks. Overall, the research aimed to expand knowledge of using circular catering practices aimed at decreasing food waste within school catering.

The research employed a mixed-methods approach beginning with a semi-structured literature review to identify circular catering practices and their associated risks and benefits. Then, expert interviews with practitioners within the Dutch school catering sector were conducted to gather real-world insights into implemented circular catering practices along with their perceived benefits and risks.

The literature highlighted a range of circular catering practices focusing on food waste prevention (e.g., menu planning, educational campaigns), reduction (e.g., simplifying menus, portion control), and reuse (e.g. food waste platforms and using leftovers). Practitioners primarily focused on reduction strategies, and less on prevention and reuse practices. Both literature and practitioners recognized cost savings, environmental benefits, and improved efficiency as key benefits of circular catering practices. Practitioners expressed risks regarding food safety, staff training, student acceptance, and time constraints, highlighting the practical challenges of implementing circular catering practices.

Overall, this research revealed a complex landscape of circular catering practices aimed at reducing pre-consumer food waste within school catering systems. Results suggest there is a need to bridge the gap between the most circular catering practices within the ‘prevention’ food waste hierarchy tier and their practical application in school catering systems. Addressing the concerns of practitioners and providing support systems are crucial for successful circular catering practice implementation. Future research should focus on facilitating the adoption of circular catering practices, conducting a risk-benefit analysis for post-consumer circular catering practices, developing tailored interventions, and fostering collaboration among stakeholders to promote a holistic approach to food waste reduction in school catering.

1.0 Introduction

1.1 Circular catering background

1.1.1 Food waste problem in catering

Food waste is a global issue in the terms of sustainability, food security, and economics that compounds as populations grow. While food waste is being tackled expansively throughout the food system, the repercussions are still hefty; it costs the global economy roughly 1 trillion USD yearly, exacerbates global food insecurity issues, and generates up to 10% of global greenhouse gas emissions (United Nations Environmental Programme, 2024). Food waste can be categorised as either avoidable or unavoidable. Avoidable food waste consists of the discarded edible parts of food products (such as blemished fruits) which can be found throughout food systems and accounts for an estimated 322 million tonnes of global food waste responsible for a waterfall of effects such as squandering energy and water (Coudard et al., 2021).

One sector of the food system that creates large amounts of avoidable food waste is catering. According to the Food and Agriculture Organization of the United Nations (FAO), this sector has compounding stages within its supply chain that contribute to higher food waste including storage loss, preparation loss, kitchen waste, buffet table waste, and plate waste (FAO, n.d.). The European Union (EU) defines catering services as the preparation, storage and, where appropriate, delivery of food and drinks for consumption by the consumer/client/patient at the place of preparation, at a satellite unit, or at the premises/venue of the client (Boyano et al., 2019). A large section of catering is institutional catering: catering that provides meals for large populations daily in contexts such as schools, hospitals, armies, and corporate cafeterias (Chaudhary & Sharma, 2023). The large scale of these locations makes institutional catering a significant contributor to food waste and a critical area for intervention and research, especially in the current push for circular economy practices (Chaudhary & Sharma, 2023).

1.1.2 Circular economy push in the catering sector

Presently, the European Commission (EC) is pushing the food system towards circularity to minimise, avoid, and recycle waste streams in the most sustainable ways (European Commission, 2020). In response, several governmental efforts have been geared towards decreasing food waste within the catering sector. For example, there is the “Dutch National Economy Program (Nationaal Programma Circulaire Economie) 2023-2030” that includes the transformation of pilot sectors and incorporates the following goals for the catering sector specifically: reduction of CO₂ emissions, decreasing animal protein, reduction of unsustainable single packaging, increased use of return packaging, and increased reporting of food waste (Greer et al., 2020; Ministerie van Algemene, 2023; Rood et al., 2017). Circular economy practices in the catering sector can be described by the term ‘circular catering’. Circular catering aims to optimise resources and involves initiatives to achieve zero waste, maximise food resources, and extend the life cycle of food products at enterprise and customer levels (Greer et al., 2020). The term encompasses the procurement, production, business operations, assortment choice, and the use of residual flows within catering sectors (Greer et al., 2020). Although governmental efforts are being made to transition the

catering system to be more circular, the implementation of circular catering practices is still in its initial phases.

The governmental drive for circular catering practices in the EU has led to other initiatives to stimulate circular catering to combat food waste. For example, the ‘waste-free catering’ project and the Together Against Food Waste (Samen Tegen Voedselverspilling) foundation are working to measure and decrease food waste from catering while providing suggestions on how to decrease catering food waste in the Netherlands (New Insight in Understanding of Waste Issues in Corporate Catering, 2024). Additionally, the EU is co-funding projects such as the foodCIRCUS project that focuses specifically on keeping food waste out of Central Europe’s schools using circular methods such as repurposing waste for insect feeding (Reducing Food Waste at Schools through Repurposing, 2024). While such social efforts are valid and can benefit the areas they target, they illustrate the barriers to implementing circular catering and systematic changes which require ample efforts from all parties involved in the catering sector.

Consequential to environmental impacts as well as government and societal pulls, the topic of food waste within catering systems has also inspired research studies to identify practices that decrease food waste within the food system and describe the barriers for implementation. Vizzoto et al. (2021) focused on the food service sector in general, identifying over 200 strategies to reduce food waste. The study also stated there is a clear misalignment between practitioners and scholars for what they thought were the most important strategies. While the study thoroughly laid out and mapped food waste reduction strategies, it did not analyse the applicability of the strategies within specific food service types. Another study, by Cardenas et al. (2024), illustrated circular practices in the hospitality catering sector through the food waste hierarchy: prevention, minimization, reusing, recycling, recovery, and disposal. Although this study focused on a specific sector of catering, the findings might not translate to all catering sectors and also did not include the necessary parameters for implementing circular practices to mitigate food waste. Greer et al. (2020) focused specifically on the drivers and barriers of diffusion of circular catering models in a case study in the Netherlands; drivers included market pressure, meeting the growing demand for sustainable alternatives, and higher-level mandates while barriers included strategies being too radical and underlying cultural obstacles in the field. The study also highlighted the need for more empirical studies within catering. Although the push for circular catering is clear within governmental sectors, social initiatives, and scientific research, empirical research focusing on specific institutional catering sectors would benefit their implementation.

1.1.3 Risk-benefit analysis of circular catering in schools

Within the current literature on circular catering, the transition and basis for research focuses on the benefits within the following 3 sections: economic, social, and environmental categories. Based on a report of only pre-consumer waste in catering companies, the average benefit: cost ratio for food waste reduction was greater than 6:1 over 3 years, and the average company saved more than 5 cents on every dollar of the cost of goods sold (Clowes et al., 2018). Socially, food waste counteracts food security, and some circular practices aimed at decreasing, such as food donations, also aim to decrease food insecurity within certain communities. Moreover, several environmental benefits have been attributed to circular catering practices designed to decrease food waste. In an extrapolation of case studies, Beretta & Hellweg (2019) estimated that food waste reduction

practices in the food service industry, including catering in school canteens, could save 4.9%, and in extended scenarios, up to 8.3% of the climate impacts of food consumption.

While existing literature focuses on the benefits and implementation of circular catering practices within the catering sector, the risks associated with that implementation are critically understudied. For example, one well-documented method for the disposing of food waste is through donation, but there is a lack of important food safety policies to guide these measures (Mossenson et al., 2024). An Australian study found that 4% of donated food posed an unacceptable health risk to consumers (Mossenson et al., 2024). Another example considers food waste recycling and reusing methods as highlighted in Cardenas et al. (2024) and Vizzoto et al. (2021). The studies recommended using takeaway containers as a method of recycling food waste and company use of leftover food as a method of reusing food waste. However, there are food safety risks associated with such practices that were not discussed within the scope of the research described in Koppel et al. (2016). This study, which focused on the food leftover practices among consumers in Europe, South, and North America, found that potentially risky behaviours were observed in every country studied. For example, participants left food out at room temperature for several hours before storing it in the refrigerator, which increases the risk of foodborne illness (Marklinder et al., 2013). A further circular catering practice with associated risks is using food waste for animal feed. Dame-Korevaar et al. (2021) performed a literature study highlighting that feeding the consumption-phase food waste to pigs and poultry had various microbial health hazards including parasites in pigs and mycotoxins in poultry. The risks of implementing circular catering need to be compared to the benefits to decide whether the practices are worth the benefits or if the risks are too high. Then, mitigation measures for the risks could be identified to take advantage of the benefits.

Conducting a risk-benefit analysis within a specific sector of institutional catering would enable the implementation of food waste reduction practices. Within industrial catering, school cafeterias are a significant source of daily food waste. Global studies focusing on school cafeterias have estimated that 17.4% (Kasavan et al., 2021), 17.5% (Silvennoinen et al., 2019), and 15% (Falasconi et al., 2015) of all food prepared, avoidable food was wasted. Food waste in school catering settings also highlights additional concerns about meeting the nutritional needs of school children (Malefors et al., 2022). School meals are planned based on official nutrition and health recommendations in some countries, so it is critical the dishes are consumed as planned and are not wasted (Nationella Riktlinjer För Måltider i Skolan, 2018). Additionally, economic stress can also impact how meals are planned within countries, especially since COVID-19 created increased food insecurity problems in many countries such as the Netherlands (Cash and Voucher Assistance at Scale, 2023). In response, the Netherlands has created a programme that allows schools to sign up for free school meals for their students or get money for grocery shopping (Cash and Voucher Assistance at Scale, 2023). While health and nutrition are priorities of school cafeterias, policies and programs, such as the Dutch programme, do not mention a push towards circularity or efforts to reduce food waste. For these societal and governmental pushes, the Dutch school catering systems would benefit from a risk-benefit analysis for implementing circular catering practices to decrease food waste.

1.1.4 Problem Statement

While the societal and governmental pushes for circularity within the catering sector highlights the benefits of adopting circular catering practices, the risks involved in their implementation have not

been systematically analysed and discussed. Furthermore, to the best of our knowledge, there are no previous studies that assessed circular catering practices specifically within the scope of school catering and examined both the risks and benefits of implementing such practices. A holistic risk-benefit analysis has not yet been conducted to explore the economic, societal, and environmental implications of circular catering practices aimed at decreasing food waste within the school catering sector.

1.2 Demarcation of research, study aim, and research questions

1.2.1 Dutch secondary school catering focus

The EU leading member states in circular economy are Germany, Italy, France, Belgium, Spain, and the Netherlands (Castillo-Díaz et al., 2024). However, there are still critical gaps in waste management in all member states which require different approaches due to diverse economic and social situations among the various countries. One EU country that is specifically committed to decreasing food waste is the Netherlands. The Dutch central government has created several efforts to decrease national food waste including the National Circular Economy Program 2023-2030 with the goal of halving food waste by 2030 through the implementation of permanent efforts. The Netherlands has also set benchmark goals to monitor total food waste in the Dutch food supply chain annually, reduce and prevent food waste through the Food Waste Free United Foundation voluntary agreement, and make funding available for joint research into food waste prevention and uses for surplus food (European Food Loss and Waste Prevention Hub - Explore the Member States Initiatives, n.d.). Although many efforts are being made throughout the food system in the Netherlands, efforts are still needed to reach the country's food waste reduction goal, including in educational settings.

The school catering sector is included within the term 'institutional catering' as defined by Chaudhary & Sharma (2023), and for this research, 'institutional school catering' the Netherlands can be defined as food served in canteens of educational institutions. It is common to find canteens in higher education within the Netherlands, and school catering within secondary schools could be growing in response to the School Lunch Programme (Programma Schoolmaaltijden) (Cash and Voucher Assistance at Scale, 2023). Since most Dutch primary schools do not have cafeterias, they were not included in the scope of this study. Consequently, this research included institutional school catering in Dutch educational institutions from secondary schools to higher education establishments and focused on the implementation of circular catering practices at their level.

1.2.2 Pre-consumer food waste focus

Within the context of the catering sector, the avoidable food waste can be described as pre-and post-consumer. In school catering, pre-consumer food waste was reported to be prevalent, and it includes preparation, storage, and delivery (Kasavan et al., 2021). Additionally, post-consumer food waste-reduction practices are generally less effective in schools due to internal and external factors such as attitudes, habits, social norms, and environmental context (Abe & Akamatsu, 2015). Due to heterogeneity in age, location, and other internal and external factors within the scope of this research, post-consumer circular catering practices were not included. Therefore, this study focused on circular catering practices in the pre-consumer phases from food entering the schools up to it reaches the consumers.

1.2.3 Research aim and questions

This research aims to gain an in-depth understanding of the risks and benefits associated with implementing circular catering practices in the Dutch school catering sector aimed at decreasing food waste. Catering practices that can affect food waste will be identified and the benefits and risks associated with circular catering practices will be analysed through a semi-structured literature review and expert interviews. The research is expected to contribute to the knowledge regarding the potential risks and benefits associated with circular catering practices focused on decreasing food waste.

The research questions 1-4 were made to facilitate discussion of all components in a risk-benefit analysis including risk characterization, benefit characterization, and a risk-benefit comparison (EFSA, 2010).

Research Questions (RQ):

RQ1. What circular catering practices can decrease pre-consumer food waste in school catering according to the literature?

RQ2.

a. What potential benefits are associated with the circular catering practices identified in RQ1 according to the literature?

b. What potential risks are associated with the circular catering practices identified in RQ1 according to the literature?

RQ3. What circular catering practices are being used that decrease pre-consumer food waste in school catering according to practitioners?

RQ4.

a. What potential benefits are associated with the circular catering practices according to practitioners?

b. What potential risks are associated with the circular catering practices according to practitioners?

2.0 Research Methodology

First, a semi-structured literature review was conducted to identify relevant circular practices aimed at decreasing food waste in pre-consumer school catering settings to answer RQ1. Within the semi-structured literature review, the risks and benefits of the identified practices in RQ1 were indicated to answer RQ2. The purpose of these interviews was to answer RQ3 and RQ4 and obtain current insights on circular catering practices used to decrease food waste within the Dutch catering sector. The interviews were conducted with experts in the Netherlands and in the English language. The risks and benefits were compared by analysing the aggregated insights from the literature review and from practitioners of circular practices in Dutch school catering using the risk-benefit analysis steps described by EFSA (2010). AI was not used as a methodological tool during the completion of this research.

2.1 Semi-structured literature review

First, a semi-structured literature review was conducted to identify literature findings on circular catering practices in pre-consumer, institutional school catering (RQ1). The literature review also included identifying the risks and benefits associated with these practices (RQ2).

2.1.1 Search criteria

The standardisation for the semi-structured research included clearly defining inclusion and exclusion criteria to remain aligned with the research aim and research questions. Table 1 outlines the inclusion and exclusion criteria for the semi-structured literature search. Although the research focuses on catering in the Netherlands, only English literature was considered to make this research accessible to the researcher and to ensure replication. While the ‘circular economy’ term was created in the 1980s, its use within the food sector did not start until 2010, so publications before 2010 were not included (Winans et al., 2017). The research location was not limited to the Netherlands, as these circular practices identified for RQ1 are not strictly geographically related, allowing for a broader scope beyond the Netherlands. Additionally, geographical influences were analysed in the semi-structured interviews. Also, risks and benefits were excluded if they were not specific to the circular practices found in RQ1.

Table 1. Semi-structured inclusion and exclusion criteria for the literature review

Criteria	Inclusion	Exclusion
English	If literature is in English	If literature is not in English
Relevant literature	If the publication date is after 2010	If the publication date is before 2010
Research type	If empirical studies, university research, reviews, meta-analysis	-
Peer-reviewed	If peer-reviewed	If not peer-reviewed
Duplicates	-	If a duplicate or very similar paper by the same authors
Institutional School catering	If institutional catering is focused on school/education(al) canteens/cafeterias/cafes/foodservice settings	If institutional catering is outside of school settings such as army catering, corporate catering, hospital catering
Circular practices to decrease food waste	If circular practices are directed to decrease food waste	If circular practices are not directed to decrease food waste
Circular practices pre-consumer	If circular practices are before the consumer receives the food	If circular practices post-consumer
Circular practices applicable for school catering	If circular practices apply to school catering	If circular practices do not apply to school catering settings
risks	If risks are associated with circular catering practices identified in RQ1	If risks are not associated with circular catering practices identified in RQ1
benefits	If benefits are associated with circular practices found in RQ1	If benefits are not associated with circular catering practices found in RQ1

2.1.2 Definition of core concepts

Core concepts were defined for the general aim of the study and research questions focused on during the semi-structured literature review, RQ1 and RQ2, as described in Table 2. As this research was demarcated as pre-consumer circular practices to decrease food waste within Dutch schools, the specific criteria for circular catering in this research were described in Table 2. In addition, Table 2 also includes synonyms and similar concepts used to open the literature search within the search strains in order to reach a higher amount of relevant sources.

Table 2. Core concepts and synonyms

Core concept	Synonyms
General Aim	
Circular	Environmental/low-impact/zero-waste/sustainable/renewable
Catering	Caterer, catering, canteen, cafe
Practices	methods, strategies, processes, techniques, actions, tactics, methods, strategies, rules, operations, septs, conventions
RQ1: What circular catering practices can decrease pre-consumer food waste in school catering according to literature? RQ2: What potential benefits(a)/risks(b) are associated with the circular catering practices identified in RQ1 according to the literature?	
Avoidable food waste	Avoidable/preventable/unnecessary/avertible, food garbage, food trash, food rubbish, food scraps, food waste matter, food waste products, food waste material, leftovers
School catering	school(s), education, canteen(s), cafeteria(s), cafe(s)

2.1.3 Definition of search strategies

A series of search strains with combinations of core concepts listed in Table 2 were created based on RQ1 and RQ2 for the semi-structured literature search (Table 3). Search strings were searched in databases Elsevier’s Scopus advanced search to achieve the largest collection of relevant, top-level, peer-reviewed journals for life sciences, and social science, with health and industrial focuses. This search method was chosen to best align with the scope of this research while encompassing all areas of potential risk and benefits associated with school circular catering practices. Additionally, snowballing was used during this literature review, meaning additional sources found within the scientific articles were used in addition to the hits from the search strings. Search string diaries along with the database found, hits, relevant hits, snowballing, and total relevant hits per research question are included in Table 3. The first search string had 16 relevant hits, but the second search string was done to broaden the hits, using less key words in the search, which resulted in 12 more relevant hits- totalling 28 relevant hits. The relevant hits were first used to identify circular practices that decrease food waste in catering (RQ1) and then were analysed to look for risks and benefits associated with the circular practices (RQ2). RQ2 did not use its own search string to avoid confirmation bias to favour information for either risks or benefits of circular catering practices. In addition, ATLAS.ti software was used to analyse the most common keywords within the literature search and compare them to the search string terms. All articles were downloaded into the programme. Exclusions of keywords were pronouns, adverbs, prepositions, conjunctions, and determiners while inclusions were nouns, adjectives, verbs, and adverbs.

Table 3. Search string dairies used

Search String Diary	Database	Hits	Relevant hits	Snowball hits	Total Relevant Hits
RQ1: What circular catering practices can decrease pre-consumer food waste in school catering according to literature? RQ2a: What potential benefits are associated with the circular catering practices identified in RQ1 according to the literature? RQ2b: What potential risks are associated with the circular catering practices identified in RQ1 according to the literature?					
KEY (" cater*" AND "food waste") TITLE-ABS ("circular" OR "renewable" OR "low-impact" OR "zero-waste" OR "sustainable") AND "cater*" AND ("school*" OR "education*" OR "canteen*" OR "cafe*" OR "cafeteria*") AND "food waste" AND ("practices" OR "methods" OR "strategies" OR "processes" OR "techniques" OR "actions" OR "tactics" OR "methods" OR "strategies" OR "rules" OR "operations" OR "steps" OR "conventions" AND NOT "hospitals" AND NOT "arm*" AND NOT "corporate" AND NOT "air*") AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English"))	Scopus	45	11	5	16
KEY (" cater*" AND "food waste") TITLE-ABS ("circular" OR "renewable" OR "low-impact" OR "zero-waste" OR "sustainable") AND "cater*" AND ("school*" OR "education*" OR "canteen*" OR "cafe*" OR "cafeteria*") AND "food waste" AND NOT ("hospitals" AND NOT "arm*" AND NOT "corporate" AND NOT "air*") AND PUBYEAR > 2009 AND PUBYEAR < 2026 AND (LIMIT-TO (LANGUAGE , "English"))	Scopus	83	11*	1	12

*Repeats assessed for eligibility from the first search string were not analysed during the second search string

2.1.4 Selection and analysis of articles for the literature review

After the articles were identified using the search strings, the selection of articles began with reading the titles to determine their relevance to the research questions. Next, screening was completed by reading the abstracts to ensure that the methodology, aim of the study, and results were aligned with the aim, research question, and inclusion criteria of this research. Figure 1 illustrates the selection process for articles included in the review from the articles identified in the database.

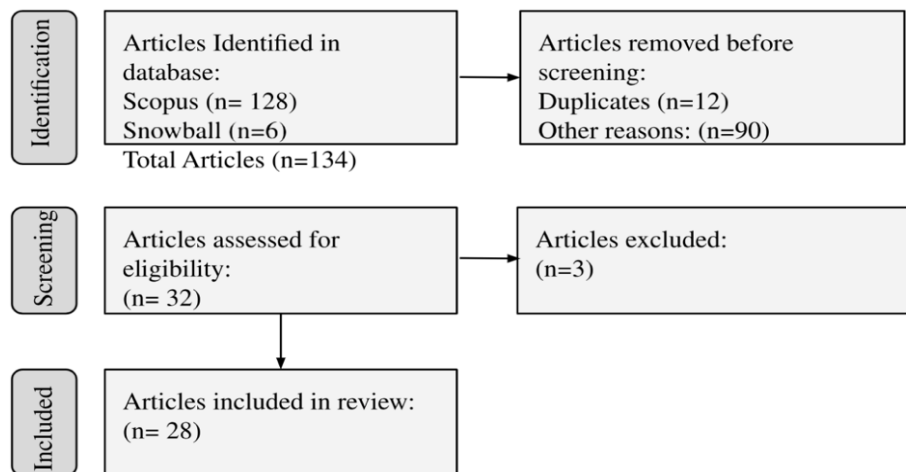


Figure 1. Flow Diagram for the selection process of articles

The included articles were then read further and analysed for findings using critical appraisal questions (Table 4). When studies were referenced while answering critical appraisal questions, those sources were analysed for alignment with the research aim, and further analysed if deemed relevant; such sources are described as snowballed in Table 3. Critical appraisal questions were created to methodically analyse the selected and snowballed articles to answer RQ1/RQ2 and are listed in Table 4.

Table 4. Critical Appraisal questions for RQ1 and RQ2

Research Applicable	Question	Appraisal Questions
RQ1: What circular catering practices can decrease pre-consumer food waste in school catering according to the literature?		<ol style="list-style-type: none"> 1. Which circular catering practices described in these sources apply to school catering? 2. Why are the circular practices described in these sources considered to be ‘circular’? 3. Which part of the catering supply chain do the practices take part in? 4. Which circular catering practices described in this source are pre-consumer? 5. How can these circular catering practices described in this source decrease food waste in schools? 6. How can these circular catering practices be categorised within the food waste hierarchy (Figure 2)?
RQ2: What potential benefits (a) and risks (b) are associated with the circular catering practices identified in RQ1 according to the literature?		<ol style="list-style-type: none"> 1. What benefits (a) are associated with the circular catering practices identified? 2. What risks (b) are associated with the circular catering practices identified? 3. How can the risks and benefits found be categorised within the following categories: availability, economic, knowledge, nutrition, regulatory, safety, and sustainability?

2.1.5 Analysis of the selected articles

The analysis of information to determine the relevancy of the articles and critical appraisal questions were gathered in an Excel file for RQ1 & RQ2 (example sections in Appendix 1). To begin, for each selected article, information about the title, authors, journal information, aim, main results of the study, type of study, data collection methods, location of the data, type of risk/benefit, relation to catering, and circular practices were found. Next, the selected articles were analysed using the specified critical appraisal questions (Table 4) related to research questions 1 and 2. Then, the information from the selected articles was systematically extracted and similar patterns in data from (multiple) relevant articles were synthesised and labelled (i.e. the so-called synthesised and categorised findings). The main results were analysed to identify the circular catering practices, how the circular practice could decrease food waste in school catering, the possible risks of the catering practice(s), and the possible benefits of the catering practice(s).

During the analysis for RQ1, practices found within the literature were grouped into inductive categories of circular catering practices. Then, the food waste hierarchy (Figure 2) was used to deductively categorise the circular catering practices (Cardenas et al., 2024). The comparison of waste hierarchy framework for analysing the circularity in Europe (Zhang et al., 2022) highlights that waste hierarchies can be adjusted depending on their goal. Consequently, the categories

chosen - prevent, reduce, reuse, recycle, and recover - highlight the scope of this research. The highest level of circularity is prevention, as this decreases the overall amount of waste before entering the food waste cycle, so it is situated at the top of the hierarchy, as indicated by the arrow in Figure 2. These categories are a mix of the 4 Rs of circular economy (reduce, reuse, recycle, and recover) and the EU waste hierarchy (prevention, reuse, recycling, recovery, and disposal) (Zhang et al., 2022). The categories highlight the pre-consumer and circular lens for the scope of this research; consequently, there is a lack of a ‘disposal’ category on the bottom level of this hierarchy. Using a hierarchy increase understanding of which practices can be more circular than others during the risk-benefit analysis and for implementing practices within school catering settings (i.e. practices higher in the food waste hierarchy). Definitions of the selected categories in the hierarchy were derived from Cardenas et al. (2024) and are listed in the hierarchy (Figure 2). These definitions were used to group the circular catering practices identified in the literature search.

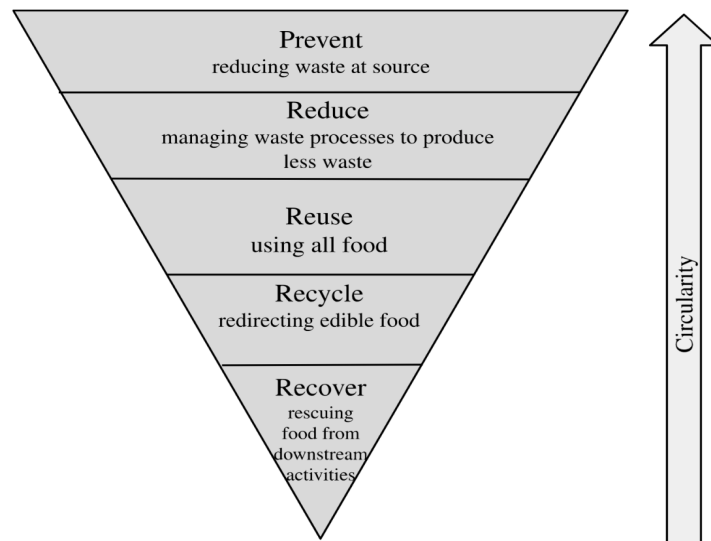


Figure 2. Food waste hierarchy adapted after Cardenas et al. (2024) & Zhang et al. (2022)

During the analysis of RQ2, the inductive categories for the circular catering practices, as created during the literature search of RQ1, were used to identify the associated risks and benefits of the practices. First, the broad definitions of risks and benefits, adopted from EFSA’s Guidance on risk-benefit assessment of foods (Committee et al., 2024) were used to identify risks and benefits within the selected literature. ‘Benefit’ (broad) is defined as a positive effect and/or the reduction of an adverse effect of a circular catering method, and ‘risk’ (broad) is defined as an adverse effect of a circular catering method. The broad risks and benefits were grouped into 3 categories based their impact: the environment, the society, and the economy (Seberini, 2020). Using a holistic risk-benefit analysis enables the gain of knowledge on how practices impact society as a whole as described by Membré et al. (2021). Social implications can be further divided into nutrition, availability, knowledge, regulatory, and safety subcategories. Definitions for each category (Table 5) were used to determine the appropriate grouping of risks and benefits found within the literature search for RQ2.

Table 5. Risk and benefit categories used to analyse the risks and benefits of circular practices

identified within the literature search

Category	Definition
Social	effects that a particular product or service can have on society (Social Benefits, n.d.) <ul style="list-style-type: none">- nutrition: potential impacts on human nutritional health (Membré et al. 2021)- availability: (in)sufficiency of staff/equipment/materials needed for a practice (What Is Resource Risk Management?, n.d.)- knowledge: losses/gains of knowledge when implementing a practice (Durst & Zieba, 2020)- regulatory: impact of regulations on the practice (Hayes, 2024)- safety: potential impact of a hazard (chemical, biological, physical) (EFSA, 2010)
Economic	potential for financial loss/gain due to change (Economic Risk, n.d.)
Environment	potential consequences of the health of the environment (EFSA, 2024)

Then, the benefits and risks went through a second screening to identify the ones that directly impacted food waste using specific definitions for the scope of the research. The definitions used during the second screening were as follows: ‘benefit’ (specific) is defined as a positive effect and/or the reduction of an adverse effect of a circular catering method that prevents, reduces, reuses, recycles, or recovers food waste within school catering, and ‘risk’ (specific) is defined as an adverse effect of a circular catering method that prevents, reduces, reuses, recycles, or recovers food waste within school catering.

2.2 Semi-structured expert interviews design

Expert interviews were designed to obtain insights from the practice into the risks and benefits of circular practices in Dutch school catering aimed at decreasing food waste. The insights were further used to achieve a holistic risk-benefit analysis. Using the literature review results, subsequent expert interviews were conducted. The semi-structured interviews were used to gain insight into the current practices implemented in Dutch schools and answer RQ3 and RQ4 with a practical lens. The interviewed experts had varying experience with Dutch school catering, ranging from secondary to higher education, and were either canteen staff members or employees of institutional catering companies providing services to Dutch schools.

2.2.1 Design of the expert interview

The structure of the interview consisted of an opening introduction, introduction questions, setting the scope, interview questions aligned with research questions split into three sections, and a closing/thanks. The entire interview guide can be found in Appendix 2.1. The interview was semi-structured with open questions to allow more information to be shared with the interviewer. Figure 3 was developed by adapting the steps proposed by Roodhuyzen et al. (2017) to fit the pre-consumer scope of this research by adding ‘transportation’ and ‘reuse’ while ‘consumption’ was switched to the term ‘serving’. The figure was used in the interview to break up the sections of the catering supply chain while identifying circular catering practices. Figure 3 was used to help guide interviewees to think about circular catering practices that decrease food waste along with their risks and benefits within each specific step of the diagram. The questions were designed to encourage interviewees to describe circular practices along with their risks and benefits throughout the pre-consumer catering steps and to clearly align with RQ3 and RQ4a/b.

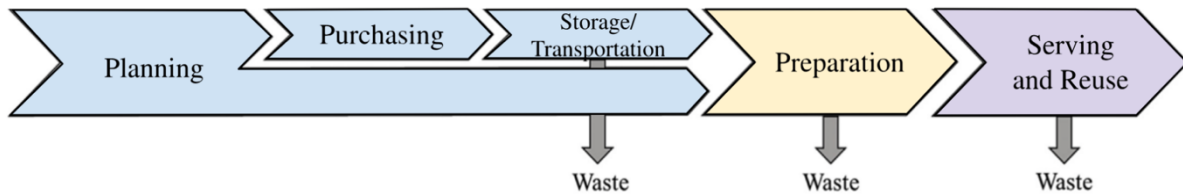


Figure 3. Pre-consumer catering steps (Adapted from Roodhuyzen et al., 2017)

2.2.2 Expert selection and research strategy

The first step in the selection process of experts was to conduct an online search for school catering companies and in the Netherlands that offer catering using search strings on Google. Schools within less than 2 hours away from Wageningen via public transit were considered for in-person interviews. The search strings included: “secondary schools with canteens in the Netherlands”, “HBO school near me”, and “secondary schools near me”. Additionally, schools were identified using the “Study in NL” website to further identify higher education schools to contact. Another method was using the researcher’s personal network to get into contact with catering companies and schools. Catering companies were identified using the search string on Google: “catering companies school canteens in the Netherlands”. Efforts to contact experts included using emails, LinkedIn Direct messages, and phone calls. The profiles of the interviewed experts are found in Table 6. An Excel file documented all data related to school identification and recruitment (including search strings, contact information, and response tracking), interview logistics (dates, interviewees, format), and assigned code names. To keep interviewees anonymous, this data is not included in the qualitative data analysis. Prior to conducting interviews, the interviewees signed a consent form (unsigned example Appendix 2.2). The interview data was pseudonymised, so the interviewees were referenced as they listed in Table 6 which includes their type of work.

Table 6. Interviewee code names and work type

Code Name	Work Type
Expert 1	Digital Catering Company working with Dutch Catering companies that supply Dutch Schools with food
Expert 2*	Dutch Private Primary-Secondary School
Expert 3*	Dutch Secondary vocational education (MBO)/Senior general secondary education (HAVO) School Canteen
Expert 4	Dutch Research University/ HAVO
Expert 5	Dutch Research University
Expert 6	Catering company supplying food to Dutch schools

*Experts answered a written questionnaire

2.2.3 Conducting interviews

Interviews were offered to be held in person or virtually. During all interviews, the interviewer took notes to record on the spot important details using a pen and paper. Expert 5 had an in-person interview and recording and transcription methods in the meeting included voice recording on Mac Quicktime player and voice typing in a Word document. Experts 1, 4, and 6 had virtual interviews on Microsoft Teams. Recording and transcription methods during virtual interviews included the use of the voice recording and transcription features in Microsoft Teams and voice typing in a

Word document. Experts 2 and 3 did not have time within the working day for in-person or virtual interviews due to their responsibilities during that time, so they answered the interview questions via a written questionnaire with the same questions, so they could complete the questions whenever they had the time. The written questionnaire can be found in Appendix 2.3. Interviews and questionnaires were conducted in English.

2.2.4 Qualitative data analysis

After the interviews were conducted, qualitative data analysis was carried out to extract relevant and useful information for the aim of the study. This was done using content analysis as outlined in Vaismoradi et al. (2013) to identify themes within the interviews. First, transcriptions of the interviews were read while the audio recording played to change any incorrect words or phrases that the transcript had. Then within an Excel file, one sheet has expert responses for all questions asked within the interviews. In addition, separate sheets were made based on the separate sections of the interview guide based on the three separate sections of the catering system. Within each sheet, each question was processed using relevant data from the transcriptions. Within the sheets, tables were made to analyse the data using the following headings: expert, unit of analysis, context unit, core of meaning, and category as seen in Appendix 2.4 and 2.5. For each question, relevant text from each expert was systematically read to extract the relevant text (context unit) which contained keywords (units of analysis). Then, when similarities of context units were seen, cores of meaning were assigned and grouped between expert answers. For circular practice identification (RQ3), units of analysis were words and phrases to describe the circular practices and how they decrease food waste, so when experts identified the same practices, they both had the same core meaning. The same was done when identifying the benefits (RQ4a) and risks (RQ4b) of the discussed practices, but in those cases, the cores of meaning were the risks or benefits discussed. Lastly, using the cores of meaning and expert responses, answers could be paraphrased to make a description of the circular practice, risk, or benefit as described.

After the responses were analysed, the circular practices (cores of meaning) were then organised per catering section based on the circular catering practice identified in the literature search. This was done to categorise the circular catering practices within the food waste hierarchy, identify the level of circularity for each circular practice mentioned, and compare results from the literature search to the expert interviews.

3.0 Results and Discussion

3.1 General trends of the semi-structured literature review

In total, 28 sources were analysed in the semi-structured literature review of circular practices to decrease food waste in school catering. In Figure 3, the publication trend can be seen for all documents used within the semi-structured literature review.

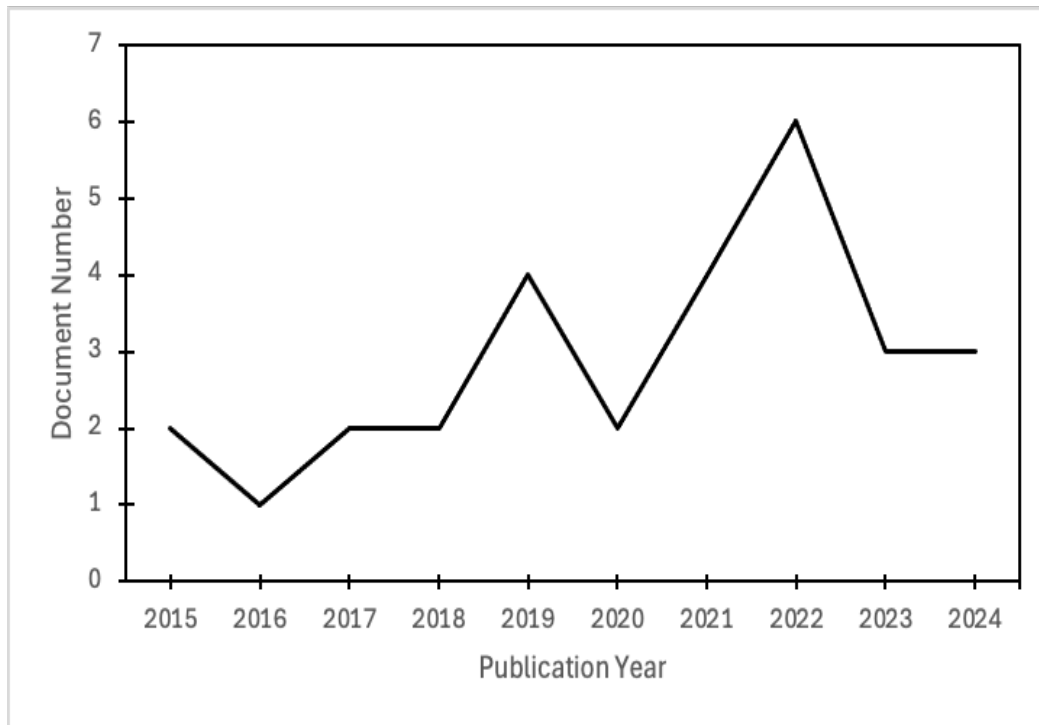


Figure 3. Publication dates of semi-structured literature search

Overall, there is a general increase of publications that describe decreasing food waste practices within catering systems. There is a dip in publications in 2020 which could be due to the COVID pandemic when catering systems were not open. The dip could have caused the incline of publications from the 2021-2022 peak to compensate for publications that were on hold during the COVID pandemic.

Table 7. Identified, grouped, and labelled pre-consumer circular catering practices (CP) categorised in the food waste hierarchy

CP groups	Further description of the circular catering practices based on literature findings	Possible relation with food waste reduction
Prevent –proactively reduce food waste at the school (most circular in food waste hierarchy)		
1. Measuring Food waste	<ul style="list-style-type: none"> Measuring food is discussed to identify the problematic sections for catering steps and enables better planning for future meals which decrease food waste. ^{3, 11, 13, 18, 19, 23, 25} 	Measuring food waste is crucial to determine whether methods being implemented to decrease food waste are working and assist creation of methods to prevent food waste within the catering system in place.
2. Improving meal planning	<ul style="list-style-type: none"> Menus that are planned based on experience, observation of food popularity, and food waste measurements are used decrease food waste at schools. ^{3, 9, 17, 19, 23, 25} 	Planning menus by making changes to meals based on consumer* preferences, can be used to prevent plate and serving food waste.
3. Using educational campaigns	<ul style="list-style-type: none"> Studies demonstrated educational campaigns increase awareness among consumers about food waste, the importance of decreasing food waste, and students’ roles to decrease food waste ^{3, 4, 9, 10, 14, 15, 16, 17, 19, 23, 24, 25, 26, 27, 28} 	Educational campaigns in schools could prevent food waste at school canteens through food waste awareness.
4. Providing tasting spoons	<ul style="list-style-type: none"> Providing tasting spoons in canteens were suggested to decrease food waste by allowing consumers to taste dishes before committing to a full portion. ^{10, 16} 	Allowing consumers to taste foods before taking a full portion can be used to prevent plate food waste.
5. Developing incentives at schools	<ul style="list-style-type: none"> Incorporating incentives (verbal or material rewards) to consumers can improve the drive to eat the vegetables and fruits in their meals.⁹ 	Incentivising practices to prevent food waste at schools can be used to motivate staff and consumers.
6. Adding a school garden	<ul style="list-style-type: none"> Adding a school garden was discussed to promote food system education and can supply cafeterias with foods used for catering services to decrease CO₂ in the catering sector. ¹⁴ 	Adding a school garden can be used to prevent food waste and overall CO ₂ in the catering sector by growing foods on location of use.
7. Creating advisory councils	<ul style="list-style-type: none"> This study showed that creating a student advisory council to discuss, create, and monitor methods to decrease food waste in their school facilitates changes tailored to the school. ⁵ 	Creating advisory councils could prevent food waste by facilitating/regulating circular catering practices chosen specific to the school.
8. Conducting customer forecasting and pre-ordering	<ul style="list-style-type: none"> Predicting the number of consumers (customer forecasting) using attendance patterns decreased serving food waste. ¹⁶ Pre-ordering meals helps staff members have an accurate prediction of how much of each food is needed using consumer preferences which decreases serving/plate food waste.^{9,17} 	Pre-ordering food and consumer forecasting could be used to prevent serving and plate food waste.
9. AI/technological (Internet of things(IoT)) waste analysis	<ul style="list-style-type: none"> AI can be used to better forecast the number of consumers and their food waste habits and how to decrease food waste using AI forecasting technology. ^{6, 13, 22} Analysis of food measurements collected by AI/IoT can be used to decrease food waste.⁶ 	AI/technological (IoT) can be used to prevent food waste through waste analysis and guest forecasting.
Reduce- management of waste processes to produce less waste (second most circular practice in food waste hierarchy)		
10. Conducting staff food waste training	<ul style="list-style-type: none"> Improving knowledge through staff training can encourage the reduction of food waste when staff use best practices to decrease food waste during preparation, serving, and reuse.^{9,23} Improving knowledge through staff training can encourage the reduction of pre-consumer food waste through proper measurement of food waste and how to use food waste measurements to decrease food waste throughout the school. ^{19, 23} 	Increased catering staff training could be used to reduce food waste preparation, serving, and reuse steps.
11. Hiring more qualified staff	<ul style="list-style-type: none"> Hiring qualified staff was discussed to have the potential to increase customer responsiveness for the sustainable development of catering supply chains. ²¹ Hiring qualified staff was discussed to increase the use of preparation methods that aim at the kitchen wasting less when preparing and storing food. ^{3,9} 	Hiring qualified staff could be used to reduce food waste preparation, serving, and reuse steps.
12. Adjusting catering supply transportation efforts	<ul style="list-style-type: none"> An ingredient/food quality check upon arrival and using ingredient cycles for ingredients and foods can avert unnecessary spoilage that creates food waste during the supply chain. ²³ 	Catering transportation efforts that prioritise decreasing food waste such as food forecasting using self-life, quality checks, and decreasing deliveries can be used to reduce food waste in catering systems.

CP groups	Further description of the circular catering practices based on literature findings	Possible relation with food waste reduction
	<ul style="list-style-type: none"> Increasing the acceptability of quality standards (such as accepting misshapen vegetables) also decreases food waste in the catering industry.¹⁹ Decreasing deliveries to the point of consumption decreases overall food waste and decreases other environmental impacts, such as CO₂ emissions from transportation.²¹ 	
13. Changing the canteen environment	<ul style="list-style-type: none"> Creating a less hectic environment and increasing time allowed to eat meals was discussed to enable consumers to focus on eating their food in this study to reduce food waste.⁹ 	Making the canteen environment less hectic can be used to reduce food waste.
14. Improving catering company and school relationships	<ul style="list-style-type: none"> Increased communication between catering company and canteens can aim to decrease food waste by discussing how much food is really needed, incorporating preferences of the consumers, and making necessary contract changes to decrease food waste.^{9,13,19} 	Facilitating a strong relationship between catering companies and schools increases communication and can reduce food waste through better ordering capabilities.
15. Increasing attractiveness of dishes	<ul style="list-style-type: none"> Studies demonstrated that creative menus aimed to make foods more appetising, decreased serving and plate waste.^{3,9,24} Concealing vegetables in dishes can increase vegetable consumption.²⁵ 	Attractiveness of menus increases consumption of foods, including vegetables and could reduce serving and plate food waste in schools.
16. Freezing foods	<ul style="list-style-type: none"> Freezing foods make foods last longer to avoid food waste by lengthening self-life while keeping foods safe.^{3,18} 	Freezing foods is a way to reduce food waste by extending how long foods can be stored and served.
17. Creating more sustainable menus	<ul style="list-style-type: none"> Creating more sustainable menus was discussed to decrease the amount of food waste and unsustainable practices in the meat supply chain into the catering supply chain.^{1,12,18,20,24,25} 	Creating more sustainable menus (local, organic, vegetarian, etc..) is a method to reduce food waste by choosing energy-efficient ingredients
18. Using portion control (reduced portions)	<ul style="list-style-type: none"> Reducing plate sizes and removing trays is a nudging strategy to trick consumers into taking less food and limit taking access to food that turns into food waste.^{17,24} Using smaller serving tools can reduce the food served to decrease plate food waste.¹⁴ Decreasing serving sizes decreases food waste.^{2,19,27} Giving smaller portions at the end of the meal service decreases food waste.³ Giving individualized meal sizes decreases food waste.^{3,10} Self-serving allows consumers to choose based wants and appetite to decrease food waste.²⁵ 	Allowing consumers to have individualised portions or smaller portions is a method to reduce plate food waste in school canteens.
19. Simplifying meals/menus	<ul style="list-style-type: none"> Simplifying meals/menus reduces ingredients from the supply chain and opportunities for food waste from large amounts of ingredients.¹⁷ 	Simplifying meals/menus can be used to reduce food waste throughout the catering supply chain.
20. Removing buffet style of serving	<ul style="list-style-type: none"> Studies discussed that buffet style has a large amount of serving waste due to the overproduction of food left from the buffet after food is served.^{19,23} 	Removing buffet style of serving could reduce serving food waste.
Reuse- use of all the food in the school (third most circular practice in food waste hierarchy)		
21. Using food waste platforms	<ul style="list-style-type: none"> This study demonstrated how surplus/unsold/non-aesthetic food from the community can provide free meals for schools.⁸ Food-sharing platforms can be used to sell or donate surplus/unsold/non-aesthetic foods to connect people and organisations which bridges circularity holes (missing links between water generators and potential receivers).⁷ 	Schools can use food/reduction sharing platforms to reuse food waste from the community to use it before it becomes waste. Schools can use these either by using donated food used in school meals for students or using platforms to donate foods to another part of the community to bridge circularity holes.
22. Using leftovers for next meals	<ul style="list-style-type: none"> Studies discussed reusing unserved leftovers for the next day's meal.^{19,25} Using leftovers is a way of reusing food waste.³ 	Using leftovers for future meals could reuse food that would be wasted otherwise.

¹Arrazat et al., 2024; ²Balzaretti et al., 2020; ³Betz et al., 2015; ⁴Browne et al., 2023; ⁵Byker Shanks et al., 2023; ⁶Chapman et al., 2022; ⁷de Almeida Oroski & da Silva, 2022; ⁸Deavin et al., 2018; ⁹Derqui et al., 2018; ¹⁰Economou et al., 2024; ¹¹Eriksson et al., 2019; ¹²Eustachio Colombo et al., 2020; ¹³Gokarn & Choudhary, 2021; ¹⁴Lee et al., 2021; ¹⁵Prescott et al., 2019; ¹⁶Malefors et al., 2022; ¹⁷Marais et al., 2017; ¹⁸Martindale, 2016; ¹⁹Moraes et al., 2021; ²⁰Saxe et al., 2019; ²¹Sel et al., 2017; ²²Sharma et al., 2022; ²³Silvennoinen et al., 2019; ²⁴Sullivan et al., 2021; ²⁵Sundin et al., 2023; ²⁶Vidal-Mones et al., 2022; ²⁷Wang et al., 2024; ²⁸Wilkie et al., 2015

* 'Consumer' is used to describe anyone who buys/consumes food from the canteens (e.g. students, teachers) unless otherwise specified

In total, 22 circular CPs were identified to decrease food waste based on the literature review (Table 7). Most identified practices fell under the ‘reduction’ category of the food waste hierarchy with 11 circular CPs identified, followed by ‘prevention’ with 9 circular CPs, and ‘reuse’ with two circular CPs. Within the food waste hierarchy, ‘recycling’ and ‘recovery’ categories were not identified within the literature review. This may be attributed to the overlapping definitions of reuse and recycling, as it is difficult to determine if food is being fully consumed (reuse) or diverted to other purposes (recycling).

Within the most discussed category, ‘reduce’, changes within the school setting can be clearly seen in practices such as those relating to *staff* (CP10 & CP11), the *canteen environment* (CP13), *menu changes* (CP15; CP17; CP19), and *serving methods* (CP18 & CP20). *Using portion control* (CP18) included many circular CPs. Studies tested various methods of decreasing serving sizes to decrease food waste. For example, Lee et al. (2021) tested using smaller serving tools to reduce the food served to consumers while Marais et al. (2017) and Sullivan et al. (2021) suggested reducing plate sizes and removing trays for the same outcome of decreasing plate waste through smaller portion sizes. Moreover, Sundin et al. (2023) discussed the use of self-serving food within canteens to allow consumers to choose what they want to eat and how much as a method to decrease plate waste. However, the *removal of buffet style* (CP20) is supported by research showing that it often leads to overproduction and significant serving food waste (Morales et al., 2021 & Silvennoinen et al., 2019). While practices aim to decrease food waste, they target different areas within the catering steps. *Removing the buffet style* (CP20) aims to reduce serving waste whereas *self-serving* (CP18) targets the reduction of plate waste.

Many circular CPs were classified in the ‘prevent’ category. The prevention category had a common theme of unison, mentioning several practices can be used together to prevent and continuously improve food waste reduction efforts in schools. Such methods include *creating advisory councils* (CP7), *using of AI and IoT* (CP9), and *measuring food waste* (CP1). Measuring food waste was discussed in several studies as a crucial practice to evaluate the effectiveness of waste reduction practices, and *AI technology* (CP9) can enhance these measurements by analysing food waste data to further prevent food waste (Chapman et al., 2022). Byker Shanks et al. (2023) emphasized the importance of school-specific approaches and continuous improvement when implementing circular CPs. The study highlighted the *creation of advisory boards* (CP7) as a crucial step in monitoring and refining these practices within each school setting. Consequently, this implies that food waste practices can be implemented concurrently or individually depending on the school's specific needs.

A few practices to prevent food waste also included the use of student involvement such as *providing tasting spoons* during serving (CP4), *pre-ordering* (CP8), and using verbal or material rewards as *incentives* (CP5) as well as *educational campaigns* (CP3) which were discussed heavily within the literature review. Fifteen sources mentioned this practice, although only 5 were experimental, empirical studies that proved this practice worked to decrease food waste (Browne et al., 2023; Malefors et al., 2022; Prescott et al., 2019; Silvennoinen et al., 2019; Wilkie et al., 2015). Within these studies, the educational campaigns were also executed in different ways. For example, Malefors et al. (2022) used a food waste awareness campaign with table talkers placed on canteen tables and on top of serving stations with messages such as ‘Eat as much as you can but throw away as little as you can’ while Browne et al. (2023) utilized educational posters hung

up in the canteen area. However the practice was put in place, the *educational campaigns* (CP3) all showed a decrease of food waste within the experimental studies while also illustrating that practice can be installed differently per school environment.

The least discussed circular category of circular CPs within the literature was ‘reuse,’ which resulted in 2 circular CPs found within the literature search: *using food waste platforms* (CP21) and *using leftovers for next meals* (CP22). *Using food waste platforms* (CP21) was discussed within the to help schools utilize unavoidable leftover food to address issues like hunger within communities (de Almeida Oroski & da Silva, 2022 & Deavin et al., 2018).

In conclusion, the semi-structured literature revealed a diverse range of circular CPs aimed at decreasing food waste in school catering systems on a pre-consumer scope which can be used individually or simultaneously depending on the school and their food waste goals. The current research predominantly emphasises ‘reduction’ circular CPs, which are less circular than ‘prevention’ circular CPs. While these circular CPs were all identified within the literature, to analyse their effects on the catering system, their risks and benefits within the literature were identified next.

3.3 Literature review identified risks and benefits of catering practices

3.3.1 Literature review benefits of circular catering practices

The 28 selected articles to identify circular CPs were also scanned for benefits relevant to school catering within the literature review (RQ2a). Table 8 shows the categories and descriptions of benefits associated with the identified circular catering practices relevant to school catering. The circular CPs were separated into the categories of the food waste hierarchy (prevent, reduce, and reuse). The benefits were categorized based on what is being impacted by the circular practices: economic, social, and environmental and are indicated with an “X”. The descriptions of benefits are linked to the specific categories of benefits using the letters in brackets under the “X”. The subcategories of social benefits include nutrition (potential impacts on human nutritional health), availability (sufficiency of staff/equipment/materials needed for a practice), knowledge (gains of knowledge when implementing a practice), regulatory (impact of regulations to the practice), and safety (potential impacts of a hazard (chemical, biological, or physical) on a person). Additionally, the broad benefits can be seen in Appendix 3.

Table 8. Categories and descriptions of benefits associated with the identified circular catering practices relevant to school catering

Circular CP groups	Benefit Categories			Descriptions of the categorised benefits (subcategory*)
	Economic	Social	Environment	
Food waste hierarchy category- prevention				
CP1 Measuring food waste	X [a]	X [b]	X [c,d]	a. can increase profit, increase return on investment, and overall decrease costs in the catering sector ¹³ b. can be used to measure the nutritional value of foods consumed and not consumed (nutrition) ¹⁸ c. with long-term continuous improvement reduces emissions of greenhouse gas and carbon footprint of the catering sector ^{11, 13, 16, 23} d. improves resource utilisation such as water, energy, land, and nutrients of the food ^{16, 18}
CP2 Meal planning	X [a]	X [b,c,d]	X [e,f,g]	a. saves schools money when less food is being wasted ³ b. can decrease chemical hazards such as allergens when planning dietary restrictions (safety) ⁹ c. can increase nutritional variety in school catering systems (nutrition) ⁹ d. can increase nutritional intake of students when eating more high nutritional value foods(nutrition) ²⁵ e. can decrease plate waste when preferences or personalised meals are made ^{17, 19, 25} f. can improve ingredient cycle usage to avoid unnecessary spoilage ^{3, 23} g. can be used to decrease food waste when factoring in external factors such as holidays or days of the weeks ³
CP3 Educational campaigns	X [a]	X [b,c]	X [d,e]	a. can decrease costs when less food is being wasted ²⁸ b. can increase vegetable/fruit consumption; positively influence dietary behaviours in youth (nutrition) ^{15, 25} c. can increase knowledge, awareness, and ability to decrease food waste (knowledge) ^{3, 4, 9, 17, 19, 23, 24, 26, 27} d. can facilitate long term habits to decrease food waste at school and outside of school ^{14, 17, 19, 23, 26, 27, 28} e. can decrease plate food waste in schools ^{14, 15, 16, 24, 27, 28}
CP4 Tasting spoons	-**	-	X[a]	a. can prevent plate waste by allowing consumers to make informed choices about the food they could take ^{10, 16}
CP5 food waste incentives	-	-	-	
CP6 Adding a school garden	X [a]	X [b,c,d]	X [d]	a. can supply the school with produce to be used in meals and decreases costs needed to supply them in a different way ¹⁴ b. can increase student involvement to decrease food waste within their school ¹⁴ c. can increase supply of vegetables/fruits at the school ¹⁴ d. can increase knowledge, and awareness of sustainability, food systems, and food waste (knowledge) ¹⁴
CP7 Advisory councils	-	X [a,b]	X [c]	a. can increase the food waste reduction practices have school specificity (availability) ⁵ b. can be used to target decreasing food waste of vegetable, so consumers are eating more vegetables ⁵ c. can be used to decrease food waste of vegetables at schools ⁵
CP8 Forecasting	X [a]	-	X [b]	a. saves schools money by spending less money on food ^{16, 17} b. can decrease food overproduction to decrease preparation, serving, and plate food waste ^{9, 16, 17}
CP9 AI/technological (IoT)	-	X [a,b,c]	X [d]	a. can increase food security by sensing and tracking when foods are bad before further use ²² b. increases availability of seamless data to all participants in the value catering supply chain (availability) ⁶ c. can be used to sense and track when foods are safe to eat (safety) ²² d. can be used to decrease food overproduction to decrease preparation, serving, and plate food waste ^{6, 22}
Food waste hierarchy category- reduction				
CP10 Staff training	X [a]	X [b]	X [a]	a. increases efficiency of the kitchen food preparation and saves money by wasting less food ^{17,21} b. can increase food waste awareness among kitchen staff ¹⁹ c. can decrease food waste through training staff to methods to decrease food waste at schools ¹⁹
CP11 Qualified staff	X [a]	-	-	a. increases efficiency of the kitchen food preparation and saves money by wasting less food ^{17,21}
CP12 Adjusting catering supply	-	-	X [a,b,c]	a. can avoid unnecessary spoilage through improved communication and needs from the school ²³ b. can decrease the deliveries to schools for more efficiency, decreasing CO ₂ emissions from transportation ²⁰

Circular CP groups	Benefit Categories			Descriptions of the categorised benefits (subcategory*)
	Economic	Social	Environment	
transportation efforts				c. can prevent food waste from spoilage through improving resource utilisation ^{3,23}
CP13 Canteen changes	-	X [a]	-	a. Students feel more comfortable and relaxed to waste less food ⁹
CP14 Catering company and school relationships	X [a]		X [b,c]	a. can decrease transaction and transportation costs ¹³ b. can decrease the amount food waste through better adjusted food quantities ordered and prepared ^{9, 13, 19} c. can decrease the deliveries to schools for more efficiency which decreases transportation and CO ₂ emissions ¹³
CP15 Attractiveness of meals	-	X [a]	X [b]	a. can add nutritional value by hiding them in attractive/popular meals which decreases waste of vegetables (nutrition) ^{9, 25} b. can decrease serving and plate waste of foods (vegetables specifically measured in this study) ⁹
CP16 Freezing foods	-	X [a]	X [b]	a. can be used to extend the shelf life of foods safely without growing any microbiological growth and while increasing the amount of time schools have to use the food without increasing safety risks (safety) ¹⁸ b. can be used to decrease food waste before and after preparation to safely store foods ^{3, 18}
CP17 Sustainable menus	X [a]	X [b]	X [c,d]	a. can decrease the cost of meals (in specific to more vegetarian) ^{12,20} b. can lead to an overall increased positive attitude to climate change policies in the catering supply chain ¹² c. overall environmental (greenhouse gas emissions) impact is lower when using sustainable menus ^{1,12,18,20} d. in some cases (such as when popular vegetarian meals are served) can decrease serving and plate food waste ^{1, 25}
CP18 Portion control	-	X [a]	X [a]	a. smaller serving sizes can result in stronger attitudes and personal norms in regards to avoiding plate waste ^{24, 27}
CP19 Simplifying meals	X [a]	X [b]	X [c]	a. can decrease production and preparation efforts lowering the cost of labour and materials used ¹⁷ b. makes measuring food waste and carbon emissions used in supply chain more accurate and available (availability) ¹⁷ c. can decrease energy and materials in the supply chain which decreases overall the carbon footprint ¹⁷
CP20 removing buffet	-	-	X [a]	a. can decrease over production from buffet service to decrease food waste ¹⁹
Reuse				
CP21 Food sharing platforms	X [a]	X [b,c,d]	-	a. to use for student meals can provide free/discounted meals for children ^{7, 8} b. to use for student meals decrease child hunger by providing free/discounted meals for children ^{7, 8} c. can increase nutritional variety in school catering systems (nutrition) ⁸ d. can be used to increase students access to healthier options. due to less exposure to processed packaged foods (nutrition) ⁸
CP22 Using leftovers	X [a]	-	X [b]	a. can minimize economic losses from overproduction ¹⁹ b. valorises serving waste as a strategy against overproduction ^{3, 25}

X marks that the practice has benefits within the category (and letters below correspond to the descriptions for each practice)

*subcategories of social benefits: include nutrition, availability, knowledge, regulatory, and safety

** - marks that no benefits were discussed within the articles where circular catering practices were identified

¹Arrazat et al., 2024; ²Balzaretto et al., 2020; ³Betz et al., 2015; ⁴Browne et al., 2023; ⁵Byker Shanks et al., 2023; ⁶Chapman et al., 2022; ⁷de Almeida Oroski & da Silva, 2022; ⁸Deavin et al., 2018;

⁹Derqui et al., 2018; ¹⁰Economou et al., 2024; ¹¹Eriksson et al., 2019; ¹²Eustachio Colombo et al., 2020; ¹³Gokarn & Choudhary, 2021; ¹⁴Lee et al., 2021; ¹⁵Prescott et al., 2019; ¹⁶Malefors et al., 2022;

¹⁷Marais et al., 2017; ¹⁸Martindale, 2016; ¹⁹Moraes et al., 2021; ²⁰Saxe et al., 2019; ²¹Sel et al., 2017; ²²Sharma et al., 2022; ²³Silvennoinen et al., 2019; ²⁴Sullivan et al., 2021; ²⁵Sundin et al., 2023;

²⁶Vidal-Mones et al., 2022; ²⁷Wang et al., 2024; ²⁸Wilkie et al., 2015)

Table 8 shows that most identified benefits were classified in the environmental category (26 total), followed by the social (24), and economic categories (12). Environmental benefits were prominent likely due to the inherent benefit of reducing the carbon footprint of the catering sector when food waste is decreased within it (Eriksson et al., 2019; Gokarn & Choudhary, 2021; Malefors et al., 2022; Silvennoinen et al., 2019). In addition, there were also environmental benefits discussed including improving water, energy, and land utilisation long-term (Coudard et al., 2021). Social benefits included positive impacts on staff members and consumers. Arrazat et al. (2024) found that increased *vegetarian meal options* (CP17) in French school canteens led to higher consumer satisfaction, driven by growing vegetarianism and environmental awareness among younger generations. The identified circular CPs in the 'prevention' category, despite having fewer identified practices than the 'reduce' category, showed more benefits, potentially indicating a stronger impact on food waste reduction at higher food waste hierarchy levels. However, it is notable to mention that all identified benefits were found within the literature analysed to answer RQ1, so there could be additional ones that were not identified within this semi-structured literature review.

Specific practices with the most identified benefits were *meal planning* (CP2) and *educational campaigns* (CP3) and both fall under the 'prevention' category of the food waste hierarchy. Both practices identified benefits in all three categories, so those are perceived in the literature to be the most cross-functionally beneficial to school canteens. On the other hand, no benefits were reported for in previous research for the *food waste incentives* (CP5), and only one for *using tasting spoons* (CP5).

Specifically within the 'prevention' category, several practices identified multiple social benefits, and notably, two practices fell in the safety subcategory. Within the study by Derqui et al. (2018) to identify the causes of food waste at school canteens and unveiling best practices to decrease food waste, it was discussed that improving meal planning can reduce chemical hazards when dietary restrictions, such as allergens, are taken into account. Additionally, Sharma et al. (2022) discussed that metagenomic technologies could provide assurance of biological food safety along with longevity of products in supply chains. These practices demonstrate that reducing food waste has benefits beyond environmental protection, such as better food safety in schools.

When compared to the other categories, most economic benefits were observed for circular CPs in the 'reduction' category. Economic benefits identified included decreasing costs within the catering supply chain. For example, *improving catering company and school relationships* (CP14) can benefit the beginning of the supply chain economics by decreasing transaction and transportation costs (Gokarn & Choudhary, 2021). *Staff training* (CP10), *hiring qualified staff* (CP11), and *simplifying meals* (CP19) were identified practices to increase the efficiency of the kitchen food preparation which saves money by reducing food waste as discussed in Marais et al. (2017) which identified practices of catering personnel that impacted food waste within a university school canteen and Sel et al. (2017) which created a catering model to minimize total costs within the system. At the end of the supply chain, *more vegetarian menus* (CP17) can decrease the cost of meals for consumers and schools due to the lower prices of non-meat proteins/meals. In general, economic benefits were identified throughout the catering system and the food waste hierarchy categories suggesting that decreasing food waste through circular practices is beneficial to the economy overall.

The identified benefits also gave additional insights into specific practices. Within the ‘reduction’ category, the contradicting practices for *portion control* using self-serving (CP18) (Sundin et al., 2023) and *removing buffet style* (CP20) (Moraes et al., 2021 & Silvennoinen et al., 2019), each identified one benefit. The benefit for portion control is an example of one that falls under more than one category, for smaller serving sizes can result in stronger attitudes and personal norms (social) regarding avoiding plate waste (environmental). This benefit was discussed in Sullivan et al. (2021) and Wang et al. (2024), which are different sources than the one that suggests using self-serving as a method of *portion control* (CP18), so this benefit identified does not necessarily apply to that particular practice (CP18). However, the identified benefit of *removing the buffet* (CP20) is the capacity to decrease overproduction from buffet service to reduce food waste under the environmental category, and it is specific to the practice.

Within the two ‘reuse’ circular CPs, one economic benefit and one environmental benefit were observed for *using leftovers* (CP22) while one economic benefit, three social, and no environmental were identified for *food sharing platforms* (CP21). *Food sharing platforms* (CP22) specifically highlighted unique nutritional benefits within Deavin et al. (2018), as this research studied the implementation of using surplus/unsold/non-aesthetic food from the community to provide free meals within schools. The other case for food sharing platforms is using them at the school itself to sell or donate food from the school to consumers (de Almeida Oroski & de Silva, 2022). The benefits overlapped for the two methods in the economic benefit of providing free or discounted foods and to decrease child hunger (social) but using the platforms to provide meals at schools identified two additional nutritional benefits: increased nutritional variety and increased student access to healthier options (Deavin et al., 2018).

In conclusion, the associated benefits for the literature identified circular CPs show they have comprehensive benefits. Overall, there were more benefits in the ‘prevention’ category, which is the most circular, indicating that those practices are also the most economically, socially, and economically beneficial overall according to the literature. These benefits could be useful implementing circular CPs within school catering, but to fully analyse the circular CPs for practical guidance within school catering, the risks also need to be identified.

3.3.2 Literature review risks of circular catering practices

Within the literature review, the risks were also extracted from the 28 eligible sources used to identify circular CPs (RQ2b). Table 9 shows the categories and descriptions of risks associated with the identified circular catering practices relevant to school catering. The risks of circular CPs were separated into the categories of the food waste hierarchy (Prevent, Reduce, and Reuse). The risks were categorized based on what is being impacted by the circular practices: economic, social, and environmental which are indicated with an "X". The descriptions of benefits are linked to the specific categories of risks using the letters in brackets under the "X".

When relevant, the subcategories of social risks include nutrition (potential impacts on human nutritional health), availability (insufficiency of staff/equipment/materials needed for a practice), knowledge (losses/insufficiency of knowledge when implementing a practice), regulatory (impact of regulations to the practice), and safety (potential impacts of a hazard (chemical, biological, or physical) on a person). Additionally, the ‘broad’ risks can be seen in Appendix 3.

Table 9. Categories and descriptions of risks associated with the identified circular catering practices relevant to school catering

Circular CP groups	Risks Categories			Identified Risk Descriptions (subcategory)*
	Economic	Social	Environment	
Food waste hierarchy category- prevent				
CP1 Measuring food waste	X [a,b,c]	X [d,e,f,g]	X [h]	a. can increase costs due to higher compensation (or motivations) to staff or hiring more staff ^{3, 23} b. can increase costs due to the investment in tools and methods ²³ c. may not impact profitability or lower costs ⁹ d. not feasible due to a lack of current common practice for measuring food waste in school canteens (availability) ¹¹ e. can be difficult to implement consistent, accurate, and complete measurements within the school catering sector due to the lack of staff availability and time (availability) ^{3, 16, 23} f. can require staff knowledge to analyse food waste data with variations of days/weeks/months (knowledge) ³ g. can require staff knowledge to properly separate measurements between different locations (kitchen, serving, plate)(knowledge) ²³ h. can be an inefficient practice to decrease food waste when corrective actions are not taken ¹³
CP2 Meal planning	-**	X[a]	-	a. requires availability of staff motivation and observation (availability) ^{17, 23, 25}
CP3 Educational campaigns	X [a]	X [b,c,d,e]	X [f]	a. can increase costs due to higher effort of staff requiring higher compensation (or motivations) to staff or hiring more staff ¹⁰ b. can increase costs due to the investments required to implement the practice ¹⁰ c. can require incorporation of commitment such as motivations or incentives (CP5) which requires increased effort and availability of motivations (availability) ¹⁰ d. can require post-intervention evaluations need to be done which require increased staff effort and availability (availability) ¹⁹ e. can decrease in food consumption in consumers which is a nutritional risk for meeting nutritional needs (nutrition) ¹⁴ f. can vary in success to preventing food waste in schools; in some cases, food waste was prevented in serving or kitchen sections using this method and declined in success overtime ^{16, 24}
CP4 Tasting spoons	-	-	-	
CP5 food waste incentives	X[a]	-	-	a. can increase costs in the form of incentives ¹³
CP6 Adding a school garden	X [a]	X [b]	-	a. can increase the costs due to the investment of tools, people, methods, training required ¹⁴ b. can require availability of increased effort, time, and volunteers to be successful (availability) ¹⁴ c. implementation requires a strong knowledge of food systems and sustainability for staff and volunteers (knowledge) ¹⁴
CP7 Advisory councils	-	X [a,b]	-	a. can require availability of increased effort, time, and volunteers to be successful (availability) ⁵ b. can be uncertain which methods of decreasing food waste are (more) effective (knowledge) ⁵
CP8 Forecasting	-	X [a]	X [b]	a. can require changes in routines and systems within school catering, which requires higher effort and motivation of staff (availability) ^{16, 17} b. can be incorrect when people do not act as expected, so serving waste can be increased ¹⁷
CP9 AI/technological (IoT)	X[a]	-	-	a. can increase the costs/investment due to the investment of tools, methods, training required ²²
Food waste hierarchy category - reduce				
CP10 Staff training	X [a]	X [b]	-	a. can increase the fixed costs of school catering ²¹ b. can require availability of strong commitment for long term implementation of skills learned during training (availability) ²³
CP11 Qualified staff	X[a]	-	-	a. can increase the fixed costs of school catering ²¹
CP12 Adjusting transportation efforts	-	-	-	

Circular CP groups	Risks Categories			Identified Risk Descriptions (subcategory)*
	Economic	Social	Environment	
CP13 Canteen changes	-	X[a]	-	a. can require additional effort from staff and school (availability) ⁹
CP14 Catering company and school relationships	X [a]	X [b]	-	a. can require availability of staff to increase communication and relationships with catering companies (availability) ²³ b. can require availability for added time, effort, and tools to improve communication (availability) ^{13, 19}
CP15 Attractiveness of meals	X [a,b]	X [c]	X [d]	a. can increase costs due to higher compensation (or motivations) to staff or hiring more staff for added effort required ^{3, 9} b. can increase costs because it requires long term assessment ²⁴ c. can require availability of added effort and time of staff (availability) ^{3, 9, 24, 25} d. can have variable effects on food waste due to various factors of consumer behaviour ^{9, 24}
CP16 Freezing foods	-	-	-	
CP17 Sustainable menus	-	X [a,b,c]	X [d]	a. can create resistance to changes in menus at schools ¹² b. there is a lack of available guidelines applicable to school catering to create more sustainable menus at schools (availability) ¹⁸ c. (vegetarian meals) can be less nutritious than non-vegetarian meals (nutrition) ¹ d. can be unpopular and increase food waste ^{18,25}
CP18 Portion control	-	X [a,b,c,d]	X [e,f]	a. measures could be misinterpreted by the students as a way to restrict their intake ²⁵ b. can require availability of added effort to implement long-term control and evaluation of the practice (availability) ³ c. can require students' knowledge of serving sizes to serve themselves because their perceptions of the portion sizes can contradict their actual consumption (knowledge) ¹⁷ d. can decrease intake of vegetables/ nutrients if less are being served or taken from consumers (nutrition) ²⁵ e. (self-serving) can increase food waste in popular meals because students serve themselves too much ²⁵ f. can increase the amount of food waste depending on consumer behavioural factors ²⁷
CP19 Simplifying meals	-	X [a,b]	X [c]	a. can require additional staff knowledge and expertise to use leftovers and reinvent recipes safely (knowledge) ¹⁹ b. can lead to more limited choices which leading to students not getting enough nutrients or being less satisfied (nutrition) ¹⁷ c. can lead to more limited choices which could increase plate food waste ¹⁷
CP20 removing buffet	X [a]	X [b]	-	a. can increase costs due to higher compensation (or motivations) to staff or hiring more staff for added effort required ¹⁹ b. can require more effort for staff and school due to higher time needed for preparation and serving which requires strong motivation from the staff (availability) ¹⁹
Food waste hierarchy category- reuse				
CP21 Food sharing platforms	-	X [a,b,c,f]	-	a. can require extensive communication between stakeholders which takes a lot of effort and availability of communication (availability) ⁷ b. can increase biological food safety risk if food not stored properly (safety) ⁷ c. can have a lack of regulations making it difficult to implement in the school catering setting (regulatory) ⁷ d. can be perceived sometimes as less healthy when used to supply meals to schools (nutrition) ⁸
CP22 Using leftovers	-	X[a]	-	a. is not an option for some foods under certain considerations of legislation for food safety reasons (regulatory) ³

X marks that the practice has risks within the category (and letters below correspond to the descriptions for each practice)

*subcategories of social risks: include nutrition, availability, knowledge, regulatory, and safety

** - marks that no risks were discussed within the articles where circular catering practices were identified

¹Arrazat et al., 2024; ²Balzaretto et al., 2020; ³Betz et al., 2015; ⁴Browne et al., 2023; ⁵Byker Shanks et al., 2023; ⁶Chapman et al., 2022; ⁷de Almeida Oroski & da Silva, 2022; ⁸Deavin et al., 2018;

⁹Derqui et al., 2018; ¹⁰Economou et al., 2024; ¹¹Eriksson et al., 2019; ¹²Eustachio Colombo et al., 2020; ¹³Gokarn & Choudhary, 2021; ¹⁴Lee et al., 2021; ¹⁵Prescott et al., 2019; ¹⁶Malefors et al., 2022;

¹⁷Marais et al., 2017; ¹⁸Martindale, 2016; ¹⁹Moraes et al., 2021; ²⁰Saxe et al., 2019; ²¹Sel et al., 2017; ²²Sharma et al., 2022; ²³Silvennoinen et al., 2019; ²⁴Sullivan et al., 2021; ²⁵Sundin et al., 2023;

²⁶Vidal-Mones et al., 2022; ²⁷Wang et al., 2024; ²⁸Wilkie et al., 2015)

Table 9 shows the most identified risk category found within the literature review was the social category (32 total), followed by the economic (13), and the environmental risks were the least identified (8). Throughout the practices, the risks within the environment category were least identified, likely due to the inherent environmental benefits of decreasing food waste (Table 8). The literature review suggests that most environmental risks identified were due to the possibility of not decreasing food waste when the practices are implemented and therefore, not resulting in environmental benefits of decreasing food waste. For example, *educational campaigns* (CP3) had variation of food waste reduction success within the literature, and in some cases, did not decrease food waste within certain sections of the catering system (Malfores et al., 2022 & Sullivan et al., 2021). Notably, within the *portion control* (CP18), it was even seen that self-serving food was found to increase food waste in some cases when consumers took too large of portions when popular dishes were served (Sundin et al., 2023). Additionally, circular CPs were also discussed to have variable effects on food waste due to factors of consumer behaviour within *attractiveness of meals* (CP15), *meal forecasting* (CP8), and *portion control* (CP18). Within the social risk categories, *measuring food waste* (CP1), *portion control* (CP18), and *food sharing platforms* (CP21) four or more risks were identified (including safety, nutrition regulatory, availability, knowledge social subcategories), so prior to implementing these practices, schools might consider these societal impacts. On the contrary, there were two circular CPs that did not have any risks identified within the literature review: *tasting spoons* (CP4) and *adjusting transportation efforts* (CP12). While this might suggest these practices are risk-free, the literature review only screened literature sources used to identify relevant circular CPs (RQ1), so for all practices, additional risks outside of the literature search could exist.

Within the ‘prevention’ category, *measuring food waste* (CP1) identified the most risks out of the circular CPs. Despite the recognized importance of measuring food waste in identifying areas for improvement (Table 8), economic, social availability and knowledge, and environmental risks were identified which could hinder the implementation of the practice and the discussed benefits. Eriksson et al. (2019), a study that measured the connection between food waste quantification and food waste reduction, emphasised the lack of a standardized and widely distributed measurement method which posed risks for implementation within schools. In addition, measuring food waste was discussed in terms of increased costs within several studies (Betz et al., 2015; Derqui et al., 2018; Silvennoinen et al., 2019). Schools may lack the funds, ability, or knowledge to implement accurate food waste measurement systems. This could potentially undermine the effectiveness of other food waste reduction initiatives which require measuring food waste to determine their success.

Within the ‘reduce’ category, *portion control* (CP18) identified the largest amount of social risks. Due to the possibility of consumers taking less food to reduce food waste, the investigation of goal conflicts in menu planning of Sundin et al. (2021) discussed possible risks of consumers' decreased intake of vegetables and nutrients, and possible misinterpretation of students as a way to restrict their intake. To mitigate such risks, Marais et al. (2017) and Betz et al. (2015) emphasized the necessity of comprehensive education for students and thorough training for staff prior to and during the implementation of portion control measures. Consumer satisfaction was also considered within practices and was considered a social benefit within this research. For example, *simplifying meals* (CP19) can lead to more limited choices, so consumers could be less satisfied (social) with the choices and eat less, leading to nutritional risks (Marais et al., 2017) and possibly

environmental risks of increased food waste. These findings suggest that the risks associated with circular CP implantation within schools may limit or even eliminate identified benefits.

The circular CPs in the ‘reuse’ category also identified potential risks of implementing practices. Notably, the *food sharing platforms* (CP21) identified a food safety risk, as the reuse of food through these platforms can increase biological food safety risks (de Almeida Oroski & de Silva, 2022). Related to safety, Deavin et al. (2018) also identified a lack of regulations, so implementation within a school setting could be difficult without adequate regulations to prevent biological risks when using food sharing platforms to decrease food waste. *Using leftovers* (CP22) also identified a regulatory risk related to food safety. As Betz et al. (2015) indicated, some foods cannot be reused under certain considerations such as foods that are considered unhygienic in accordance with the EU food hygiene guidelines for food safety reasons (Regulation (EC) No 852/2004). Therefore, schools need to comply with regulations when using this CP to make sure the food is considered safe to be reused for next meals, otherwise it needs to be wasted. These results illustrate the possible conflict within school catering systems between the goals of minimizing food waste, maintaining strict food safety standards, and complying with relevant regulations- especially when using ‘reuse’ circular practices.

In conclusion, the identification of risks concluded the literature-based risk and benefit identification step of a risk-benefit analysis (RQ2a&b) to help guide the school catering sector to become more circular through practices implemented to decrease food waste. The associated risks show the comprehensive economic, social, and environmental implications that the practices could pose when implementing circular CPs. Based on the literature review, the identified risks of circular CPs can make some of them difficult to implement within the school catering sector or diminish some of the identified benefits. Risk-benefit analysis of some circular CPs is dependent mostly on school resources such as funding, staff, and volunteers while others can rely on consumer variables that can be more unpredictable. Overall, comparing the risks and benefits can be helpful to understand the holistic implications when implementing circular CPs that could impact the success of the circular CP to decrease food waste through prevention, reduction, or reuse within the pre-consumer school catering sector.

3.4 Expert directional trends of circular catering

Following the semi-structured literature search, the Dutch school catering system was analysed through six expert interviews. Interviewees varied in background and roles within the industry to gain holistic insights into the circular catering practices being used in the Dutch catering system and their perceived benefits and risks (RQ3&4). Two experts handled food directly on a daily basis as staff of the canteen at secondary, MBO, and HAVO schools, one managed one canteen within a university, one managed the operations of food and beverages at all university locations, one worked at a catering company that works with many Dutch schools, while one worked at company that works with Dutch catering companies. These differences also were evident in the foods that they prepared, as the experts at primary schools and HAVO schools described a small variety of dishes available during lunch and a few snack break times such as sandwiches (cold and warm), pizzas, cookies, and fruit. This was much different from the experts that worked with or in university settings, as they described food services ranging from restaurants, cafes, grab and go kiosks, vending machines, and banqueting. These differences in scale of operations between the

schools resulted in a range of discussions regarding circular catering practices.

When asked about their personal definition of circular catering, the answers varied. One expert described circular catering in terms of how schools could be completely circular, so they gave an idealistic outlook on producing zero waste. Other experts gave examples throughout the catering system to decrease food waste and make the system more efficient. Another expert used an analogy to relate the school catering system to a DJ board, and the expert stated that circular catering includes many interconnected topics such as biodiversity, health, price for students, and CO₂ related items such as food waste, smart logistics, the protein transition, that all change when one topic is changed. As an example, the expert explained in the following quote:

“Students want low prices, but they also want healthy food, local food, but most of the [healthy, local] food is more costly than cheap meals they have now, which are probably less healthy, less sustainable. And in that analysis, you can go through all those different criteria, and they all have some kind of correlation or interference with each other.”

The different expert views on the circular CP concept suggest it is not yet a well-known concept in the Dutch school catering sector, but the identification of circular catering practices also demonstrates there is a drive to decrease food waste throughout school catering systems within the Netherlands.

3.5 Circular catering practices identified from the expert interviews

Experts throughout the Dutch catering sector were interviewed to share their thoughts of circular catering practices being used in the Dutch school catering systems (RQ3). They were asked to identify circular catering practices being used to decrease food waste within the following sections of the catering system: planning/packaging/transportation/storage, preparation, and serving/reusing. Table 10 shows circular CPs at different catering stages and their impact on food waste according to the experts. The expert-based circular practices (ECPs) were numbered based on their correspondence with the literature CP numbers. ECPs were separated into the food waste hierarchy categories (prevent, reduce, and reuse) in descending order of circularity for each section of the catering system (planning/packaging/transportation/storage, preparation, and serving/reusing).

Table 10. Circular CPs at different catering stages and their impact on food waste according to the experts

Food waste category	Literature-based circular CPs (CP#)	Expert-based circular CPs (ECP#) ^{n*}	Summarised opinions of experts regarding circular CPs food waste
Catering stages: Planning, Purchasing, Transportation, and storage			
Prevent	CP1: Measuring food waste	ECP1: using food waste measurement data to plan meals ^{3*(n=3)}	Measuring food waste prevents food waste by using data to better plan and prepare food
	CP2: Improving meal planning	ECP2: Using consumer preferences for purchasing ⁵	Purchasing ingredients and planning meals based on consumer preferences, food waste is prevented since consumers are offered what they like to eat.
		ECP3: Using data to track success of meals ¹	For meals that taken and eaten helps prevent food waste by incorporating the meal into planned meal schedules and making changes based on what does well and what does not based on the amount of waste
		ECP4: Ingredient package size purchasing ¹	Schools can better buy ingredients to prevent food waste depending on the size of the school, so amounts and sizes of ingredient containers can be adjusted to decrease food waste
	CP8: Conducting customer forecasting and pre-ordering	ECP5: menu plan for efficient use of ingredients ¹	Prevents food waste by planning what ingredients can be used in variable menu choices
CP9: Using AI/technological (IoT)	ECP6: Pre-ordering and forecasting ²	Planning amount of people and meals coming ahead of time prevents serving and plate food waste	
Reduce	CP12: Adjusting catering supply transportation efforts	ECP7: using AI to improve food waste data and to plan meals ³	AI can be used to analyse the food waste and predict more accurate meal forecasts to prevent serving food waste ⁶
		ECP8: Energy conservation through transportation reduction ²	Reducing transportation of foods to schools reduces overall food waste and decreases other environmental impacts, such as CO ₂ emissions from trucks used for transportation
	CP14: Improving relationships between catering companies and schools	ECP9: Reallocate ingredients close to expiration date ¹	When food in schools are close to their expiration date, ingredients can be sent to other schools to be used to reduce food waste
		ECP10: Adjusting contracts ²	Changing sustainability contracts with catering companies to have realistic goals will reduce food waste, as schools can comply with the contracts better
	CP16: Freezing Foods	ECP11: Temperature control of food ²	Using temperature control reduces food waste by extending shelf life of foods and using leftovers
	CP17: Creating more sustainable menus	ECP12: Sustainable sourcing ²	Sourcing ingredients for catering that are seasonal, available, vegetarian, and impacts the earth the least reduces food waste throughout the supply chain.
	CP17: Creating more sustainable menus	ECP13: Switching to sustainable options ²	Switching meals to vegetarian options and nudging more sustainable (less red meat) that are more sustainable and reduces the CO ₂ emissions and food waste in the supply chain
	CP18: Using portion control (reducing portions)	ECP14: Portion package purchasing ¹	Purchasing portion packages or sizes of ingredients that can reduce food waste because people can take the food with them and less serving waste is created
CP20: Removing buffet style of serving	ECP15: variety and choices with limited ingredients ¹	Ensures that people are happy with the meals and reduces food waste	

Food waste category	Literature-based circular CPs (CP#)	Expert-based circular CPs (ECP#) ^{n*}	Summarised opinions of experts regarding circular CPs food waste
Catering stage: Preparation			
Prevent	CP2: Improving meal planning	ECP16: Using forecast data to correctly prepare correct amounts ¹	Using data to track the success of meals and previous patterns decreases food waste by allowing staff to know how much food to make to prevent food waste under given circumstances (season, day of the week, testing, etc.)
		ECP17: Creative ingredient use ¹	Utilizing foods to make the least amount of waste prevents food waste
Reduce	CP10: Conducting staff food waste training	ECP18: Best staff practices ¹	Training staff reduces food waste using best practices to decrease food waste will increase ingredient utilization during preparation
	CP15: Increasing attractiveness of meals	ECP19: Increasing meal attractiveness ¹	Attractive food presentation influences consumer behaviour, potentially leading to increased food uptake and decreased waste
	-	ECP20: Refrain from preparing ahead of time ¹	When possible, if you avoid preparing too much food ahead of time, then there is reduced serving waste
Catering stage- Serving and Reuse			
Prevent	CP1: Measuring food waste	ECP21: measuring food waste ⁴	Measuring food waste is a preventive practice by using data to better plan and prepare food
	CP3: Educational campaigns	ECP22: Informing consumers when serving ¹	When serving new items that are part of prevents food waste or other sustainable efforts, inform them about efforts decreases food waste through awareness
Reduce	CP5: Developing food waste incentives	ECP23: Incentivizing buying foods that would become food waste ³	Incentives such as price discounts at the end of the meal service ² and loyalty apps ¹ are methods to prevent the amount of food waste produced during serving
	CP16: Freezing Foods	ECP24: Storing leftovers in the refrigerator ¹	Using temperature control reduces food waste by extending shelf life of foods and using leftovers
	-	ECP25: Giving away leftovers to consumers ³	Leftovers from canteens are given away to reduce food waste in several outlets: staff taking leftovers home ¹ , using take away containers for consumers ¹ , giving it to be used during banqueting services ¹
Reuse	CP21: Using food/production sharing platforms	ECP26: Food waste platforms ⁴	Food waste platforms can be used to sell leftovers
	CP22: Using leftovers for next meals	ECP27: Giving food to homeless shelters ¹	Giving food to homeless shelters is a way to reuse leftovers or foods that are about to go bad and will not be used at the school
		ECP28: Creative reuse of food ³	Reusing and utilizing food to their full potential avoids food waste production by valorising foods

*n=number experts that mentioned the practice
 - expresses there is no CP associated with the ECP

Table 10 shows that the ‘planning, purchasing, transportation, and storage’ section contained the most ECPs with 15 out of 28 identified within the section. The ‘serving and reuse’ section had the second most identified ECPs with 8 identified, and the ‘preparation’ section had the least amount with 5 identified ECPs. Within the categories of the food waste hierarchy, the expert interviews identified 12 ‘prevention’ practices, 13 ‘reduction’ practices, and 3 ‘reuse’ practices. While the ‘prevention’ and ‘reduction’ practices were identified throughout the sections of the school catering system, ‘reuse’ practices were all discussed in the ‘serving and reuse’ section. Table 10 also highlights that the interviews identified ECPs were aligned with the literature search circular CPs, as 26 out of 28 ECPs could be supported by the literature. Similar to the literature review results, ‘recycling’ and ‘recovery’ were not identified within the expert interviews.

The most discussed practice within the interviews was ECP2- *using consumer preference for purchasing-* as 5 out of the 6 experts discussed this practice to decrease food waste during the planning step of the catering process. One expert stated that to plan meals to decrease food waste, “understanding who your students are that you need to feed” is very important. Along with this, observations from staff are needed to adjust to the trends and patterns of the consumers. This aligned with the conclusion of Derqui et al. (2018) that observations were the most relevant factor influencing sustainability issues such as food waste in canteens. One expert explained catering staff monitored meal popularity and, upon identifying dishes with low acceptance, coordinated with the kitchen to alter production and make necessary changes. Another expert discussed their interest in *pre-ordering* (ECP6) using the following quote:

“It’s (pre-ordering) much clearer what’s really needed instead of all the waste you generate... Also people will probably be more happy because they get what they want instead of having to choose what’s being ordered... so we expect much less food waste.”

Pre-ordering (ECP6) works to prevent serving and plate waste and was discussed in the literature review specifically by Derqui et al. (2018) and Marais et al. (2017). Additionally, experts also discussed increasing sustainable actions through *energy conservation in transportation* (ECP8), *sustainable sourcing* (ECP12), *switching to sustainable options* (ECP17), and *adjusting contracts* (ECP10). Two experts mentioned that *adjusting contracts* (ECP10) between schools and catering companies to have realistic goals would help reduce food waste using concrete goals and methods. *Adjusting contracts* (ECP10) relates to *improving relationships between catering companies* (CP14) and schools as discussed within Derqui et al. (2018) where looking over contractual obligations with food waste in mind was suggested after semi-structured interviews along with food waste audits at school canteens. The research also included that within the food service sectors, other actors such as students, professors, and parents also are involved within contractual agreements and further research is needed to carry out school-based circular catering practices.

Only a few experts mentioned circular CPs during the ‘preparation’ section. For the 5 identified practices, each were discussed by one expert which could be attributed to the variation of preparation methods used throughout the Dutch school catering systems. An expert noted that school catering varies significantly between lower and higher education, influenced by factors like the size of the student population and the presence of international students. One expert explained this using the following quote:

“The Netherlands is the only country in Europe where we are used to lunch with a bun and a cup of soup... [some other] countries, they are used to eating a hot meal [for lunch]... so in the universities, we offer a lot of hot of meals ... [hot meals require] more ingredients to use [while] secondary education has the smallest assortment and products.”

Based on the interviews, larger institutions, particularly those with a higher international student (university-level schools), often offer a wider variety of food options and more hot items within their menus. This could explain why one expert discussed *refraining from preparing ahead of time* (ECP21) which was one of the two practices that did not align with the literature review. Due to the scale of meal preparation, this practice is not adaptable to the demands of Dutch higher education canteens, in contrast to the smaller-scale, as-needed preparation of cold sandwiches typical in Dutch secondary school canteens. This most relates to the practice described in Byker Shanks et al., 2023 to *create advisory councils* (CP7), as practices to decrease food waste require a level of specificity for each school.

Within the ‘serving and reuse’ catering section there was one ECP identified by half of the experts that was not associated with any literature review circular CPs: *giving away leftovers to consumers* (ECP26). This practice highlights the opportunities to give away food to several outlets such as staff taking leftovers home, consumers using takeaway containers, and banqueting services using the leftovers for their services. While this was not identified in the literature review, it is a common practice in the Dutch catering system. A more discussed practice that most experts mentioned was *using food waste platforms* (ECP26) which was identified within the ‘reuse’ section and was also found within the literature review. All of the experts identified using the same platform, Too Good To Go, in which leftover foods that have not gone bad are sold using an app at a discounted price. Based on these interviews, the use of these platforms appears concentrated in larger, higher-education schools, as they were not mentioned by experts working with secondary school canteens. Within the literature, studies also mentioned using food waste platforms including de Almeida Oroski & da Silva (2022) which studied the issues and barriers to such food waste platforms and emphasised that they are an interesting solution to food waste management but there is limited empirical knowledge on the practice’s ability to decrease food waste on a large scale.

Another notable finding from the experts within the ‘serving and reuse’ section was the differentiations of *measuring food waste* (ECP21) within the serving and reusing section and *using food waste measurement data to plan meals* (ECP1) within the ‘planning, purchasing, transportation, and storage’ section. These two practices ensure that the measurements are taken and being utilised to better plan to avoid food waste, which was explained within the literature specifically by Eriksson et al. (2019) finding that quantification of food waste alone does not guarantee decreased food waste.

In conclusion, the expert interviews revealed a diverse range of ECPs aimed at decreasing food waste in the Dutch school catering sector. In general, there were some practices that were common throughout the different outlooks of the experts, but some varied depending on the size of the school and the resources available to them, so implementation of circular practices to decrease food waste are dependent on the school size, type of school, and variable wants of the consumers within the Dutch school catering sector. Similarly to the literature review, there were more ‘reduction’ circular CPs identified than ‘prevention’, and to make a more circular school catering

system, efforts should shift to more ‘prevention’ circular CPs to oblige with the governmental push for circular catering within the Netherlands. Next, to assess the practices using a risk-benefit analysis, experts were asked to also identify the risks and benefits of the ECPs discussed.

3.5.1 Benefits of circular practices according to experts

Experts throughout the Dutch catering sector shared their thoughts of the benefits of the circular catering practices (ECP) they identified for the different sections of the catering system (planning/purchasing/storage/transportation, preparation, serving/reusing) (RQ4a). Table 11 shows the circular ECP benefits during catering stages according to the experts. ECPs are listed and separated based on the location within the sections of the catering system (i.e. Planning, purchasing, transportation, and storage). ECPs without any identified benefits are not listed in the table, but at the bottom of the table, there is a section that displays the benefits of decreasing food waste in school canteens that were not associated with a specific ECP. The expert-identified benefits were sorted into economic, social, and environmental categories and are indicated with an “X”. The descriptions of the benefits are linked to the specific categories of benefits using letters in brackets under the “X”. The subcategories of social benefits include nutrition (potential impacts on human nutritional health), availability (sufficiency of staff/equipment/materials needed for a practice), knowledge (gains of knowledge when implementing a practice), regulatory (impact of regulations to the practice), and safety (potential impacts of a hazard (chemical, biological, or physical) on a person).

Table 11. Circular CPs benefits during catering stages according to the experts

Expert Circular Practice (ECP#) ^{n**}	Benefit Categories			Benefits
	Economic	Social	Environmental	Identified Benefit Description (subcategory*) ^{n**}
Catering stages- Planning, Purchasing, Transportation, and storage				
ECP1: using food waste measurement data to plan meals ³	-	-	X [a]	a. Planning the meals to limit the amount of food waste and purchased food benefits the environment ¹
ECP2: Using consumer preferences for purchasing ⁶	X [a]	X [b,c]	-	a. Strategic food purchasing to prevent waste allows schools to feed the same number of people at a lower cost ¹ b. Incorporating consumer preferences into meal planning increases satisfaction, yielding a social benefit ² c. Staff are equipped with the knowledge to identify popular meals, enabling a proactive approach to meeting consumer demand (knowledge and availability) ¹
ECP7: Pre-ordering and forecasting ²	X [a]	-	X [b]	a. less costs overall at the school due to clearer food quantity needs, so less food is purchased in total ¹ b. forecasting the number of meals/customer to limit the amount of food waste and purchased food benefits the environment ¹
ECP8: Using AI to improve food waste data and plan meals ¹	-	X [a,b]	-	a. Using AI can better predict the amounts of foods better because it can take more factors into account to decrease food waste more (knowledge) ¹ b. Increases staff members knowledge of meals that are popular using quantitative data rather than qualitative observations to more accurately meet consumer demand (knowledge, and availability) ¹
ECP9: Energy conservation through transportation reduction ²	-	X [a]	X [b]	a. Purchasing less frequently forces schools to pre-plan meals more in advance (availability) ¹ b. Transporting food using an electric car is an environmental benefit due to less CO ₂ emissions in the supply chain ¹
ECP12: Temperature control of food ²	-	-	X [a]	a. The preservation of food through refrigeration offers a sustainability benefit to schools by minimizing waste and maximizing the utilization of purchased ingredients ²
ECP13: Sustainable sourcing ²	X [a]	-	X [b]	a. Decreased food waste can contribute to the financial viability of procuring sustainably grown products ¹ b. Purchasing products that are sustainably grown benefits nature as a whole ²
ECP14: Switching to sustainable options ²	-	X [a,b]	X [c]	a. When there are healthy, sustainable food options available, there are health benefits to consumption of these foods (nutrition) ¹ b. There are guests that appreciate and are happy that there are more sustainable options available ¹ c. Increasing sustainable options available and switched out from less sustainable options, increases sustainability ¹
ECP15: *Portion package purchasing ¹	-	-	X [a]	a. Portion-controlled packaging enhances the efficiency of food consumption, leading to a decrease in waste associated with leftover servings ¹
Preparation				
ECP18: Creative ingredient use ¹	-	-	X [a]	a. Environmental benefit to utilizing foods to make the least amount of food waste because less food is transported and emitting CO ₂ ¹
ECP20: Increasing meal attractiveness ¹	X [a]	-	X [a]	a. Appealing meal presentation increases the likelihood of consumer purchase and consumption ¹
Serving and Reuse				
ECP22: measuring food waste ⁴	X [a]	-	-	a. There are less costs to the school because measuring food waste makes it clearer what is foods are needed to avoid food waste ¹
ECP23: Informing consumers when serving ¹	-	X [a]	X [a]	a. When consumers are informed about food waste efforts and sustainability, their enthusiasm about environmental efforts to decrease food waste (environmental) and incite change in their lives (knowledge) ¹

Expert Circular Practice (ECP#) ^{n**}	Benefit Categories			Benefits
				Identified Benefit Description (subcategory*) ^{n**}
	Economic	Social	Environmental	
ECP24: Incentivizing buying foods ³	-	X [a]	-	a. The use of incentives within loyalty programs can promote healthier dietary patterns among consumers (nutrition) ¹
ECP26: Giving away leftovers to consumers ³	-	X [a]	-	a. Taking leftovers can provide individuals with a sense of contribution to food waste reduction efforts ¹
ECP27: Food waste platforms ⁴	-	X [a]	-	a. There is increased awareness when consumers can use food waste platforms ¹
Other benefits mentioned not associated with any specific practices				
	X [a]	-	X [b]	a. Decreasing food waste overall saves costs of catering since less food is wasted so less food can be purchased ¹ b. Decreasing food waste overall makes the school more sustainable as an organisation ³

X marks that the practice has benefits within the category (and letters below correspond to the descriptions for each practice)

*subcategories of social benefits: include nutrition, availability, knowledge, regulatory, and safety

**n=number experts that mentioned the practice or benefit

- marks that no benefits were discussed within the articles where circular catering practices were identified

Table 11 shows the most identified benefit category found within the interviews was the ‘social’ benefit category (11 total), followed by the ‘environmental’ (10), and the ‘economic’ (6) was the least identified. Where there were more practices, more benefits were identified, so the catering location with the most identified benefits was the ‘planning, purchasing, transportation, and storage’ section. The two practices with the most identified benefits were using consumer preferences for purchasing (ECP2) and switching to sustainable options (ECP14). While some ECPs lacked identification of any benefits in the interviews, two general benefits of decreasing food waste within schools were discussed as seen in the bottom section of the table. All identified benefits were derived within the expert interviews after the identification of ECPs (RQ3), so other benefits that were not identified within the interviews, may exist, so the research may not have captured all possibilities

‘Economic’ benefits were identified throughout the catering sections- specifically identified in association with using consumer preferences (ECP2), pre-ordering and forecasting (ECP6), sustainable sourcing (ECP12), increasing meal attractiveness (ECP19), and measuring food waste (ECP21). The following expert quote illustrates the concept of several economic benefits for circular CPs:

“As a university, you spend less money because it is much clearer what is really needed instead of all the waste that is generated”

This concept can be summarised by the economic benefit within the ‘other benefits mentioned but not associated with any specific practices’ section since decreasing food waste results in purchasing less food which decreases the schools’ costs for food. Likewise, Betz et al. (2015) discussed that decreasing food waste saves school’s money by spending less money on foods in regards to meal planning efforts.

‘Environmental’ benefits also had very similar responses across the practices and sections of the catering supply chain. All experts were aware, as in the literature search, that there are environmental benefits of reducing food waste. Decreasing food waste was mentioned as an environmental benefit when using *food waste measurement data to plan meals* (ECP1), *pre-ordering and forecasting* (ECP6), *temperature control of food* (ECP11), *portion package purchasing* (ECP14), and *informing consumers when serving* (ECP22). These correspond with the literature review that food waste reduction reduces the carbon footprint of the catering sector (Eriksson et al., 2019; Gokarn & Choudhary, 2021; Malefors et al., 2022; Silvennoinen et al., 2019). In addition, other sustainability benefits included using less transportation or using electric cars to emit less greenhouse gasses within the supply chain (ECP17 and ECP8) while *sustainable sourcing* (ECP12) and *switching to sustainable options* (ECP13) discussed increasing the overall sustainability of the catering sector when using more sustainable ingredients. These benefits relate most to improving water, energy, and land utilisation as discussed in Coudard et al. (2021).

As for the most discussed benefit category, ‘social’, experts mainly discussed consumer satisfaction, ‘knowledge’, and ‘nutrition’. Consumer satisfaction was discussed by two experts within the practices *using consumer preferences for purchasing* (ECP2) and *switching to sustainable options* (ECP13) because some guests appreciate the availability of sustainable meals. Expert quotes related to consumer satisfactions include:

“People will probably be more happy because they get what they want.”

“People are maybe more satisfied with the meals”

It is clear from the interviews, that consumer happiness contributes to the successes of circular CPs and the benefits associated with them. Within a study that tested interventions to reduce food waste in school catering, tasting spoons and pre-ordering were consumer-focused practices were tested and proved to be successful methods to decrease food waste in schools (Malefors et al., 2022).

Increased knowledge of food waste was also described as a benefit within *informing consumers when serving* (CP21) and *food waste platforms* (CP26). As for ‘nutritional’ benefits, *switching to sustainable options* (ECP13) and *incentivizing buying food* (ECP23) each identified one. According to one expert, if there are *sustainable options available* (ECP13), there are health benefits to the consumption of these foods. As for *incentivizing buying foods* (ECP24), one expert discussed how loyalty programmes within the school with incentives can be used to nudge students to have better eating habits (such as eating all their vegetables).

In conclusion, the associated benefits for the identified ECPs show comprehensive benefits that the practices offer throughout economic, social, and environmental implications. These results support the literature review identified benefits, as many were also perceived in practice. To more fully analyse the practice identified within the expert interviews, the risks were also identified.

3.5.2 Risks of circular practices according to experts

Experts throughout the Dutch catering sector shared their thoughts of risks for the circular catering practices (ECP) they identified for the different sections of the catering system (planning/purchasing/storage/transportation, preparation, serving/reusing) (RQ4b).

Table 12 shows the circular ECP risks during catering stages according to the experts. ECPs are listed and separated based on the location within the sections of the catering system (i.e. planning, purchasing, transportation, and storage). ECPs without any identified risks are not listed in the table, but at the bottom of the table, there is a section that displays the risk of decreasing food waste in school canteens that were not associated with a specific ECP. The expert-identified risks were sorted into economic, social, and environmental categories and are indicated with an “X”. The descriptions of the risks were linked to the specific categories of risks using the letters in brackets under the “X”. The subcategories of social risks include nutrition (potential impacts on human nutritional health), availability (insufficiency of staff/equipment/materials needed for a practice), knowledge (losses/insufficient of knowledge when implementing a practice), regulatory (impact of regulations to the practice), and safety (potential impacts of a hazard (chemical, biological, or physical) on a person).

Table 12. Circular CPs benefits during catering stages according to the experts

Expert Circular Practice (ECP#) ^{n**}	Risk Categories			Risks
	Economic	Social	Environmental	Identified Risks Description (subcategory*) ^{n**}
	Planning, Purchasing, Transportation, and storage			
ECP1: using food waste measurement data to plan meals ³	-	X [a]	-	a. Inaccurate meal or attendance forecasting poses a risk of insufficient food, potentially leading to customer dissatisfaction and nutritional deficiencies. (availability, social, nutritional) ¹
ECP4: Using consumer preferences for purchasing ⁶	-	X [a]	-	a. When consumer preferences are considered, these could be the unhealthier options (nutrition) ¹
ECP5: Ingredient package size purchasing ¹	-	X [a]	-	a. It is a not always possible for the suppliers to provide specific packaging sizes to schools to decrease waste (availability) ¹
ECP6: menu plan for efficient use of ingredients ¹	-	X [a]	-	a. Schools that serve a higher variety of warm dishes use more ingredients, so efficiency of ingredients is less realistic (availability) ¹
ECP10: Pre-ordering and forecasting ²	-	X [a]	-	a. Risk that forecasting is wrong due to unforeseen factors such as an opening of a snack bar near the school, so the quantity forecasted is incorrect (knowledge) ¹
ECP11: Adjusting contracts ²	X [a]	-	-	a. Altering existing contracts carries potential challenges and can introduce instability into business operations ¹
ECP12: Temperature control of food ²	-	-	X [a]	a. Environmental risk of using high energy consumption for cool storage ¹
ECP13: Sustainable sourcing ²	X [a]	X [b]	-	a. Choices that are more sustainable might not be those that are discounted when purchasing, so they could be more expensive ¹ b. While promoting sustainability, sourcing practices may necessitate a reduction in menu options, potentially impacting consumer preferences ¹
ECP14: Switching to sustainable options ²	-	X [a]	X [b]	a. There are guest that are unsatisfied with canteens making sustainable changes (i.e. less meat options) ¹ b. plant-based meals can lead to more complaints and more food waste when meals are not appealing ¹
ECP15: *Portion package purchasing ¹	-	X [a]	X [b]	a. There is a regulatory risk because single use plastics are regulated in the catering industry (regulatory) ¹ b. There is more pre-packaged plastic use which is an environmental risk ¹
Preparation				
ECP19: Best staff practices ¹	X [a]	-	-	a. Implementing best practices for food waste reduction necessitates a financial commitment to staff training ¹
Serving and Reuse				
ECP22: measuring food waste ⁴	-	X [a]	-	a. Measurement of food waste can be hindered by practical constraints, specifically the significant time and effort involved (availability) ¹
ECP24: Incentivizing buying foods ³	X [a]	X [b]	X [a]	a. Implementing end-of-period discounts may inadvertently incentivize the purchase of only discounted items, potentially decreasing overall sales and increasing food waste b. could promote eating more unhealthy options when those are leftover or reaching expiration (nutrition) ¹
ECP25: Storing leftovers ¹	-	-	X [a]	a. Environmental risk because the plastic being used is not being properly recycled within the school catering system ¹
ECP26: Giving away leftovers to consumers ³	-	-	X [a]	a. The practice of taking leftovers may not effectively reduce food waste if these items are ultimately discarded uneaten ¹

Expert Circular Practice (ECP#) ^{n**}	Risk Categories			Risks
	Economic	Social	Environmental	Identified Risks Description (subcategory*) ^{n**}
ECP27: Food waste platforms ⁴	-	X [a,b,c]	-	a. When consumers eat leftovers, this could lead to overeating which is a nutrition risks (nutrition) ¹ b. Some foods cannot be reused food using waste platforms due to food safety/hygiene regulations (regulatory) ³ c. Food safety risks of giving away foods that are regulated, so the responsibility of food safety problems is a risk (safety) ¹
ECP28: Giving food to homeless shelters ¹	-	X [a]	-	a. Food safety risks of giving away foods that are regulated, so the responsibility of food safety problems is a risk (safety) ¹
Other risks mentioned not associated with any specific practices				
	X [a,b]	X [c]	-	a. Changing systems requires added effort and often include economic investments in technology and incentives ¹ b. In businesses, the finance is more important than waste or sustainability point of view ¹ c. Aversion to disrupting established practices, rooted in concerns about potential risks, impedes systemic change in companies and schools ¹

X marks that the practice has risks within the category (and letters below correspond to the descriptions for each practice)

*subcategories of social risks: include nutrition, availability, knowledge, regulatory, and safety

**n=number experts that mentioned the practice or benefit

- marks that no benefits were discussed within the articles where circular catering practices were identified

Table 12 shows most identified risk category found within the interviews was the ‘social’ risk category (15 total), followed by the ‘economic’ (6) and ‘environmental risks’ (6). There were more risks listed where there were more practices identified, so the catering sector with the most identified risks was the ‘planning, purchasing, transportation, and storage’ section, so that section identified the most risks. Several of the ECPs identified did not have associated risks discussed within the interview. Although there were almost as many risks identified as benefits, in a few cases, experts stated that “there are no risks” while this was not a response when discussing the benefits. Similarly to the expert-identified benefits in Table 11, at the bottom of the table, three risks were discussed based on practices to decrease food waste at schools that were not associated with any specific practice. Since identified risks were derived within the expert interviews after the identification of ECPs (RQ3), other risks that were not identified within the interviews, may exist, as the interviews may not have captured all possibilities.

The ‘environmental’ risks were one of the least identified, due to the inherent environmental benefit of decreasing food waste. Similarly to the literature review, environmental risks identified were based on the risk of food not being decreased after implementing a practice. This was discussed within switching to sustainable options (ECP13), incentivising food (ECP21), and giving away leftovers to consumers (ECP 26). When comparing the risks to benefits of these practices, it is evident that implementation is dependent on the target consumer group, so measuring the food waste amounts would be a helpful tool to understand when a practice is successfully decreasing food waste. Unfortunately, in the case of giving leftovers to consumers, it is not possible to keep track of food waste when it leaves the canteen.

‘Economic’ risks highlighted that implementation of the practices can involve economic investments in technology and incentives, and implementation of practices do not always decrease costs. One expert elaborated on this risk in regards to *adjusting contracts* (ECP10) to have more *sustainable* (local in the example) *sourcing* (ECP12) saying:

“With working locally, that means changing your entire supply chain...that means that you have to break some bonds you have and that’s scary business-wise.”

Interestingly, there were some practices discussed in the expert interviews that were implemented but were stopped due to economic and environmental risks. One expert discussed *incentivizing buying foods* (ECP23) as a previously used practice, but it ended up making more food waste since people would wait for the discounted product, and fewer people than anticipated took the food overall. Controversy, another expert also described this practice but discussed a nutritional risk instead. This again highlights that implementing practices are school-dependent and are influenced by many factors.

‘Social’ benefits were overwhelmingly the most identified risk. In many cases, availability was a topic of discussion for risks but not benefits, which is the only category of risks and benefits where the risks outweigh the benefits. This holds true when comparing results to the findings of the literature review as well. For example, *measuring food waste* (ECP21) identified the risk that implementing measuring food waste takes too much time to do daily and too much work to implement. According to Chapman et al., 2022 there are currently technological programmes that can measure food waste (CP9), so it is less time-consuming for staff members, but these also require availability to install and pay for the devices. From the risk tables within the literature

review (i.e. Tables 8 and 9) and expert interviews it appears that while the methods could be valuable to incorporate, there are availability risks that keep methods from being implemented at school canteens.

Other subcategories of ‘social’ risks included ‘safety’ and ‘regulatory’. Specifically, *food waste platforms* (ECP26) risks were discussed by three of the four experts that identified the practice as an ECP. There are food waste risks linked to giving away foods since they are regulated, so the responsibility for the food waste is a risk to the school. However, the literature review stated the lack of regulations make food sharing platforms difficult to implement (de Almida Oroski & de Silva, 2022). Based on interview findings, it seems as if there are current regulations to use these food waste platforms, but there is still a food safety risk. It is possible that could be due to the formation of the EU Platform on Food Losses and Food Waste which has developed guidelines for food waste topics such as using food waste platforms. *Giving food to homeless shelters* (ECP27) was discussed as a previously employed practice, as it was discontinued due to food safety liability, but the development of EU guidelines within the EU food waste platform may facilitate its reinstatement within school canteens.

In conclusion, the associated risks for the identified ECPs are critical to compare to their associated risks and benefits when implementing circular CPs to understand their implications on economics, society, and environment. The results suggest that it can be helpful to analyse how the practices impact each other when considering implementation. Experts also insinuated that the Dutch school catering sector is not capable of a fully circular catering system where it stands now, but there are currently practices being done to decrease food waste within all sections of the catering system.

3.6 Overall discussion

After analysing the qualitative data obtained from the experts, the literature search was enhanced with additional circular catering practices and expert insights on circular catering within Dutch education. The results showed an integration of the literature in a practical setting, and the similarities of identified circular CPs can be seen in Table 10. Two circular CPs mentioned by experts, but absent from the literature review, highlighted gaps in the current research or the literature search.

Across both data sources, ‘reduction’ practices demonstrated the highest prevalence, both within the literature and as currently implemented within the Dutch school catering sector. However, the ‘prevention’ category, as the most circular tier, was associated with more benefits than ‘reduction’ practices, suggesting that ‘prevention’ circular CPs offer both increased circularity and potentially superior benefits for school catering.

Based on the current results, a comparative risks-benefit analysis of individual practices can inform strategic prioritisation of circular CPs and guide the school catering sector towards circular catering with minimal risks and maximized benefits. However, the importance of the context-specificity of the assessments was highlighted, as optimal circular CP selection will vary among the different schools even in the same country. A holistic risk assessment framework is essential for a comprehensive understanding of circular CP implications. Specifically, the identification of risks such as safety concerns allows for proactive mitigation strategies, preventing potential health issues within the community. Holistic analyses across other risk categories (economic, social, and

environmental) are necessary to minimize the broader impacts of implemented circular CPs. This research further suggests that the implementations of existing circular CPs need to be subjected to ongoing risk-benefit evaluations to facilitate continuous improvement and optimize food waste reduction strategies among school catering systems.

In conclusion, circular catering practices aimed at decreasing food waste are integrated throughout the food waste hierarchy and have risks and benefits that effect their integration and success. Therefore, careful consideration of school-specific contexts, implementation of continuous improvement protocols, and risk-benefit analysis are vital for ensuring the effectiveness and long-term viability of circular catering initiatives.

3.7 Methodological considerations

Overall, the semi-structured literature review and expert interviews within the Dutch school catering system were conducted sufficiently to obtain exploratory research on the pre-consumer circular catering practices to decrease food waste and their risks and benefits. However, limitations of this study's method support the need for future research within the field of circular catering. Within the literature review and interviews, the categorization of some practices within the food waste hierarchy and benefit/risk categories presented challenges due to the overlapping of categories. Future research could benefit from the development and application of more rigorous categorization criteria and definitions to enhance the clarity and consistency of data analysis. Furthermore, the risk and benefit identification relied solely on literature to explore circular catering practices (RP1). Future research should consider looking at different outlets (i.e. grey literature) or other search strategies for a more widespread identification method of benefits and risks.

Regarding the interviews specifically, the reliance on non-face-to-face methodologies represents a key limitation, for only one of the six interviews was held in-person. Out of the other five interviews, three were conducted via video call and two were administered via an online questionnaire. Although these alternative methods facilitated participation within different outlets of the school catering system in the Netherlands, they likely impacted the depth and richness of the data collected. Specifically, the online questionnaire responses resulted in fewer details for data collection, even with identical questions asked. While acknowledging the pragmatic advantages of online and written communication in terms of minimizing researcher travel and participant time commitment, face-to-face interviews would have been preferable for enhancing responses for facilitating richer dialogues and data collection. Furthermore, the interviews were conducted in English, a non-native language for all participants which could have constrained the interviewees' ability to fully articulate their insights. Future research should prioritize conducting practitioner interviews in the participant's native language to maximize data depth and validity.

4.0 Conclusions and recommendations

4.1 Research conclusions

This research has illuminated a comprehensive landscape of circular CPs with significant potential for implementation within school catering systems. By examining the interconnected economic, social, and environmental risks and benefits of these practices, this study offers a holistic and exploratory outlook. The findings discussed the most benefits within the environmental category by reducing CO₂ emissions and promoting resource efficiency through using the circular CPs. These practices offer a pathway towards mitigating climate change and fostering ecological sustainability within the food system. Furthermore, the research highlighted the social benefits including the potential to alleviate child hunger, enhance environmental and nutritional literacy among students, and improve overall consumer satisfaction with school meals. Economically, the study demonstrates that reducing food waste through circular CPs can generate significant cost savings for school catering systems by minimizing resource expenditure. However, the implementation of circular catering practices is not without risks. The research identified social risks as the most prominent, for successful implementation requires availability of adequate resources and infrastructure, which may be difficult for some schools. Moreover, the study acknowledges that the effectiveness of these practices to significantly reduce food waste is not guaranteed. In instances where waste reduction targets are not met, potential environmental and economic risks may occur, including the possibility of increased waste generation and financial losses.

During the literature review, 22 circular CPs were identified that can decrease pre-consumer food waste in school catering (RQ1). Within the literature, the 'reduce' category found the most circular CPs, and 'reuse' circular CPs were the least identified. Due to the higher rank of circularity, prevention practices should be prioritized to increase circularity within school catering systems. The findings of the literature review included some practices that can be done in combination (such as implementing food waste measurements and using AI/IoT technology) while others cannot benefit from this (removal of buffet style and self-serving to reduce portion size). It was also noticed that certain circular CPs within the same food waste hierarchy tier also differ in their target location to decrease food waste (such as reducing serving waste or reducing plate waste). This suggests further research is needed to investigate the effectiveness of simultaneous circular implementation.

Within the 'prevention' category, the highest number of benefits were identified for the circular CPs, supporting the prioritization of these practices to increase circularity in school catering. There were the most environmental benefits identified while there were the least amount of environmental risks identified. This result suggests that using circular CPs to decrease food waste are beneficial to the environment overall. Although several circular CPs were associated with having economic benefits, these benefits were the least identified within the literature. On the contrary, the identified economic risks suggest that circular CPs can increase the costs when implementing circular CPs due to initial investments, fixed costs, and adequate compensation to staff- even though wasting less food can also save money. Similarly, the majority of circular CPs offered social benefits, suggesting that their implementation in school canteens can improve social

areas such as safety, nutrition, availability, and knowledge. However, social risks were also identified throughout the circular CPs including areas such as availability, safety, nutrition, knowledge, and regulatory. Based on the literature results, circular CPs have overall positive impacts on the environment, can decrease costs within the catering sector, and improve social conditions such as societal knowledge of food waste. Because implementation depends on addressing societal risks and securing funding, a risk-benefit analysis and continuous improvements of practices are essential for school canteens.

The expert interviews identified 28 circular catering practices that can decrease pre-consumer food waste in school catering (RQ3). These findings generally aligned with the identified literature review circular CPs, for 26 out of 28 ECPs could be associated with 17 out of 21 literature review identified circular CPs. Experts described the circular CPs by the location of the practice, and the most identified school catering section were stages prior to preparation (planning, purchasing, transportation, and storage) while the least discussed section was preparation. Within the food waste hierarchy categories, experts also primarily focused on reduction methods. Again, although 'reduction' circular CPs contribute to increasing circularity, the lack of 'prevention' circular CPs identified suggest that the catering system still has opportunities to further improve. This suggests a need for further investigation into the barriers hindering the implementation of preventive measures.

After the identification of circular CPs, associated economic, social, and environmental benefits (RQ4a) and risks (RQ4b) were analysed within the literature. Through the interview, it was notably clear that cost savings, environmental responsibility, and increased efficiency were common benefits associated with circular CPs throughout the catering system. However, practitioners express stronger concerns regarding risks such as food safety, staff training needs, student acceptance, and time constraints. These practical challenges underscore the importance of context-specific solutions and support systems for successful circular CP implementation. While the literature provides a valuable theoretical framework, the practical realities faced by catering staff needs a more individualistic approach. As discussed, effective implementation of circular practices requires customization to the unique characteristics of each school.

In conclusion, this research contributes valuable insights to the understanding of risks and benefits associated with circular CPs to decrease food waste within the school catering sector. These findings can inform decisions by school administrators, policymakers, and food service professionals seeking sustainable and resource-efficient catering models. Successfully decreasing food waste in schools requires a holistic and collaborative approach. This includes integrating theoretical knowledge with practical considerations, developing tailored implementation strategies for individual schools, and exploring innovative approaches to maximize the effectiveness of circular practices. Future research should prioritize these areas, fostering continuous improvement and collaboration among researchers, policymakers, and practitioners to achieve decreased food waste in catering and contribute to a more sustainable, equitable, and resilient food system for future generations.

4.2 Recommendations for Dutch school catering practitioners

To move towards more circular catering, school catering could prioritise circular CPs that contribute to food waste prevention, such as using food waste measurements to plan menus and

quantities, implementing pre-ordering and forecasting systems, and engaging students in menu planning. Implementation of circular CPs aimed to use data for continuous improvement (e.g. improving planning, using AI/IoT, measuring food waste) to decrease food waste could have variable benefits depending on the school and outlet of the catering system. Schools can consider implementing circular CPs based on short-term and long-term impacts on food waste and their targeted location. This way, short-term practices (i.e. educational campaigns) can work to decrease food waste within the schools while long-term, systematic practices (i.e. measuring food waste and implementing pre-ordering and forecast systems) are being ingrained in the catering sector to decrease food waste at a larger scale.

During the implementation of circular CPs, it is crucial to understand the economic, social, and environmental risks and benefits of circular CP implementation and understand the relationship between the practices and how they can impact each other. Research findings indicate that the combined application of circular CPs, such as food waste measurement and AI/IoT technologies, can be an effective strategy for promoting continuous improvement. On the other hand, some practices cannot be implemented at the same time such as the removal of buffet style and self-serving as a method to reduce serving sizes. To choose circular CPs best suited for each school based on variable factors between the schools (such as size, age, and international consumer population), schools can consider creating advisory councils. Such councils choose which circular CPs are used and then also monitor the continuous improvement efforts needed for the circular CPs in place to adjust as needed to decrease as much food waste as possible within the school. However, the implementation of most of the identified CPs need support, commitment, and availability of resources within the schools since it can be difficult to change practices within the current catering system. Therefore, collaboration between school staff, students, and catering companies is essential for successful implementation and long-term impact. By considering these recommendations, Dutch schools can not only reduce their environmental footprint but also cultivate a culture of mindful consumption and waste reduction among future generations. Investing in implementing these sustainable practices is an investment in the economy, society, and environment, contributing to the overall health and well-being of the school community.

4.3 Further research recommendations

Based on the outcomes of this exploratory study, there are several future research needs that can be considered. This research focused on pre-consumer food waste in school catering, but the literature also identified many other practices that were post-consumer, which did not fit within the scope of the research. Therefore, further research could investigate post-consumer waste to complete the food waste hierarchy analysis. The literature review also enabled the identification of CPs that are not directly applicable at the school level (e.g., regulatory adjustments, guideline development). They were excluded from the analysis but warrant further investigation due to their potential system-wide impact. In addition, it could also be of scientific interest to conduct observations at school canteens throughout the Netherlands aimed at identifying the circular catering practices in place. During such visits, interviews could take place in person for a richer analysis of the current circular catering situation within the Netherlands.

In general, a holistic risk-benefit analysis of circular catering in corporate settings could also be researched to further support broader adoption and contribute to EU and Dutch circularity targets.

Furthermore, circular catering beyond waste reduction would also further the development of circular catering, so future studies could explore interconnected areas like energy use (transportation, equipment), and food sourcing (organic, reduced meat consumption) to identify best practices for school catering and other food system sectors. Lastly, further analysis and comparison of the benefits and risks of circular catering within the Dutch context is crucial for informing policy, practice, and guidelines on a regulatory level to incite pragmatic changes within the Netherlands and beyond.

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Appendix

Appendix 1: Excel Examples during literature review RQ1

Appendix 1.1 Relevance of the articles assessed for RQ1 example in Excel sheet

Title	Authors	Journal Information	Aim of Article	Main Results	Type of study (review, empirical, viewpoint...)	kind of data collection method (survey, interview, analytical)	location of data	relation to school catering	relation to circular catering	relation to decreasing food waste
Healthy Planet, Healthy Youth: A Food Systems Education and Promotion Intervention to Improve Adolescent Diet Quality and Reduce Food Waste	Melissa Pflugh Prescott 1,* Xanna Burg 1, Jessica Jarick Metcalfe 1, Alexander E. Lipka 2, Cameron Herritt 3 and Leslie Cunningham-Sabo 3	Nutrients	The primary purpose of this study was to examine the impact of a student-driven sustainable food systems education and promotion intervention on adolescents' food selection, consumption, and waste behaviors, particularly for fruits and vegetables, during school lunch. In addition, we aimed to understand the influence of the intervention on students' knowledge and attitudes towards the food system and to estimate the intervention acceptability and fidelity.	Our study demonstrated that food systems education implemented by science teachers can be used to improve fruit and vegetable consumption and wasting behaviors during school meals	case study: Overview of the Healthy Planet, Healthy Youth experimental embedded mixed methods Figure 1. Overview of the Healthy Planet, Healthy Youth experimental embedded mixed methods design, including timeline of intervention and data collection. Rectangular elements illustrate data collection, where blue signifies quantitative data and yellow signifies qualitative data. Oval elements collection, where blue signifies quantitative data and yellow signifies qualitative data. Oval elements illustrate intervention points and duration of intervention. The dotted line indicates that the poster illustrate intervention points and duration of intervention. The dotted line indicates that the poster content analysis results were used to develop the cafeteria poster intervention	The Healthy Planet, Healthy Youth (HPHY) study used an experimental embedded mixed methods design [29], in which the qualitative data were embedded within and generally played a supportive role in the non-randomized controlled trial which was primarily based on quantitative data. The qualitative data consisted of student posters and teacher interviews. Quantitative data was on measured food waste.	United States	conducted at middle school cafeterias	the study focused on decreasing food waste, which is a circular catering practice	the study focused on decreasing food waste by implementing curriculum on sustainable food system, addressing environmental impacts of food choices and food waste and included a school wide promotional campaign to discourage food waste

Appendix 1.2: Example of Critical Appraisal Questions for RQ1 in Excel sheet

1) Which circular catering practices described in these sources are applicable to school catering	2) Why are the circular practices described in these sources considered to be 'circular'?	3) Which part of the catering supply chain do the practices take part in?	4) Which circular catering practices described in this source are pre-consumer?	5) How can these circular catering practices described in this source decrease food waste in schools?	Were the circular catering practices effective in the study
Educational and promotional campaign for decreasing food waste and addressing environmental impacts of food choices and sustainable food systems in general	the study focused on decreasing food waste, which is a circular catering practice	pre-consumer	Educational campaign	this decreases food waste by having the kids involved in curriculum based specifically on food waste, so they can be more aware of it, why it is important, and what they can do to help decrease food waste	Yes, At five months follow up, the intervention group wasted significantly less salad bar vegetables compared to the control group (24.2 g and 50.1 g respectively (p = 0.029)). These findings suggest that food systems education can be used to promote improved dietary behaviors among adolescent youth.

Appendix 1.3: Example of critical appraisal questions for RQ2 in Excel sheet

		Critical appraisal questions			
strategie from RQ1	source from RQ1	What benefits are associated with the practices associated with the circular catering practices?	How can the benefits be categorised? safety economic, availability, sustainability, social, nutrition, and regularotry, knowledge .	What risks are associated with the practices associated with the circular catering practices?	How can the risks be categorised? safety economic, availability, sustainability, social, nutrition, and regularotry , knowledge
Environmental changes to the eating spaces (making lunch longer and less loud/crowded)	(Derqui et al., 2018)	!) students feel more comformatble/relaxed to eat more	1) social	1) difficult to implement	1) economic/ knowledge

Appendix 2: Interview documents

Appendix 2.1 Interview Guide

INTERVIEW GUIDE

Risk-Benefit Analysis of Circular Economy Practices in Dutch Institutional School Catering

I. Introduction

“[Interviewee's Name], thank you for taking the time to speak with me today for my thesis project; I really appreciate it. I hope you are doing well today. Before we officially start the interview and start recording, I would like to give a brief overview of the interview along with a few logistical points. I have briefly presented the aim of this project in my email, but as a refresher, my thesis topic is on circular economy practices that can be used in school catering systems to decrease food waste and how are the benefits of these practices compared to the risks they pose. The purpose of this interview is to gain a deeper understanding of the Dutch school catering system and learn about the circular catering practices that are already being used.

The main aims of the interview are to gain insights on the following:

- *The current practices that are used to decrease food waste before the food is served within Dutch school catering*
- *The potential benefits and risks of catering practices used to decrease food waste*

As a [job title of the interviewee], your knowledge in this area will be very useful to my thesis.

You have [or have not] signed the informed consent form (if they have not signed it, have them sign it), so you should know this interview is voice recorded so I can best analyse the data. Please let me know if you would like to receive a copy of the transcript.

Do you have any questions before we start the voice recording?

Great, that is all I had before we officially start, so I will start the recording now... and again, thank you for your time and cooperation.”

II. Introduction Questions

“I will begin with a few introduction questions to better know you and the catering system you work with.”

- 1) **Could you please describe your current role in school catering?**
(follow up question if they do not say in the answer)
 - a. **How long have you had this role?**

- 2) **Could you describe how the catering system you work with is set up?** (for example: who is responsible for the catering processes)

- 3) **Could you describe the food services provided?** (for example: meal types, time available, food types, consumers)
(follow up questions if they do not say in their answer)
 - a. **When is the food available to students and staff?**
 - b. **What meal types are available to them? (breakfast, snacks, lunch...)**
 - c. **What food products are available to them? (sandwiches, hot meals, sweets, drinks)**
 - d. **To how many people do you approximately serve foods/meals per day? (students/staff and how many)**

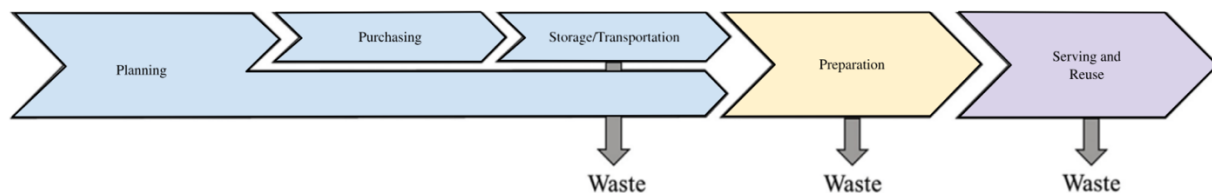
“Thank you so much for those responses, now I would like to talk about the term ‘circular catering’. Within literature, this term can be described as efforts within the catering sector to minimise, avoid, and recycle waste streams in the most sustainable way. Some examples of circular catering practices include those that reduce CO₂ emissions, decrease animal protein consumption, reduce single-use plastics, increase use of return packaging, and decrease food waste.”

- 4) **How would you describe ‘circular’ catering’?**
(follow up question if they do not say in their answer)
 - a. **What kind of practices are typical for circular catering in schools?**
 - b.

III. Setting the scope

“Now we are going to move on to more specific questions, but I would like to first describe the scope/range of my project and how the next series of questions will be asked.”

In this image, the catering steps that are within the scope of my project are shown. I am focusing on circular catering practices used to decrease food waste at planning, purchasing, storage, transportation, preparation, serving, and reuse of foods served at school canteens. I have grouped them into three sections, as indicated by the different colors.



- 5) To what extent does this figure align with your catering system?
 (follow up question if they say no and do not elaborate)
 a. Can you elaborate on the differences in your catering system?

In the next set of questions, I will ask you about circular catering practices you can think of that are currently being done within Dutch school catering in the blue, yellow, and purple sections followed by questions about the benefits and risks attached to the practices.” [for each interview, tailor this for the specific school or company]

IV. Planning, Purchasing, Storage/Transportation

“The first step of the catering system is planning which is done until the food is being prepared. Planning involves communications, such as communication between catering companies, other suppliers, and schools as well as other crucial steps like menu planning and planning order quantities, times, and foods. Purchasing includes where foods are being sourced, what is being purchased, and how much is being purchased. Storage/ transportation include steps and environments (for example coolers, temperature control trucks) used and taken to get food from suppliers to the point of preparation/school.”

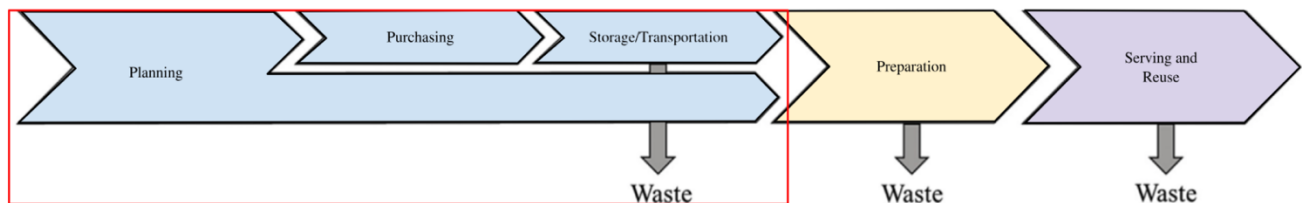
- 6) Referencing the definition of circular catering practices, can you think of any circular catering practices that are being used [at your school/company] to decrease food waste with the planning, purchasing, storage, and transportation steps specifically?

(follow up question if they say no and do not elaborate)

- a. Can you elaborate on how those practices decrease food waste?

“In the next set of questions, I would like to ask about the benefits and risks associated with the circular practices that are used at [school/company] during planning, purchasing, and storage. The Table has categories of benefits and risks (briefly explain).

- 7) Referencing the definition/categories of benefits, for each practice, describe any benefits.
 8) Referencing the definition/categories of risks, for each practice, describe any risks.



Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably
Planning: This is done until the food is being prepared. Planning involves communications, such as communication between catering companies, other suppliers, and schools as well as other crucial steps like menu planning and planning order quantities, times, and foods.
Purchasing: This includes where foods are being sourced, what is being purchased, and how much is being purchased.
Storage/ transportation: This includes steps and environments (for example coolers, temperature control trucks) used and taken to get food from suppliers to the point of preparation/school.

Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)
Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)

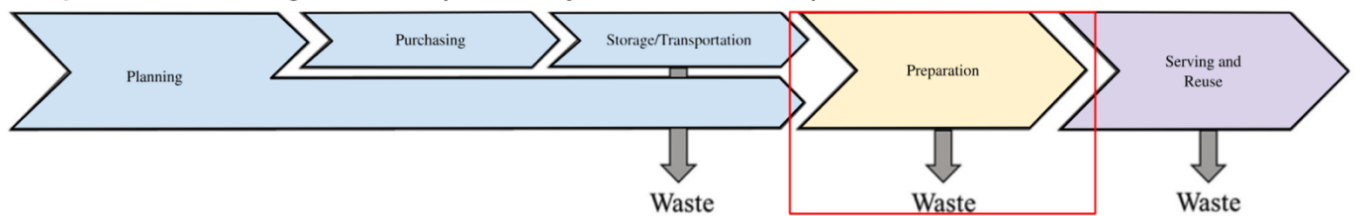
V. Preparation

“The next step is the preparation of food. This can be done in a kitchen in the school or in a different location and then delivered in a ready-to-eat form at the school. This can be done in one way or in any combination. Food that is edible and wasted in this step is the focus of this question—for example eggshells are not food waste because they are not edible.”

- 9) **Can you think of any circular catering practices that are being used [at your school/company] to decrease food waste with the preparation of foods specifically?**
 (follow up question if they say no and do not elaborate)
 a. **Can you elaborate on how those practices decrease food waste?**

“Now I would like to ask about the benefits and risks associated with the circular practices that are used at [school/company] during preparation. The same risks and benefit categories are listed.”

- 10) **For each practice, describe any benefits.**
 11) **For each practice, describe any risks.**



Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably	
Preparation: Steps taken to get food ready for serving the food; this can be done in a kitchen in the school or in a different location and then delivered in a ready-to-eat form at the school. This can be done in one way or in any combination. Food that is edible and wasted in this step is the focus of this question—for example eggshells are not food waste because they are not edible.	
Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)

Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)
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VI. Serving and Reusing

“The last steps that I am looking at are the practices used to decrease food waste during the serving of the food and of food reuse within the canteen (such as if foods are prepared but then used the next day if they were not taken).”

12) Can you think of any circular catering practices that are being used [at your school/company] to decrease food waste with the serving/reuse of foods specifically?

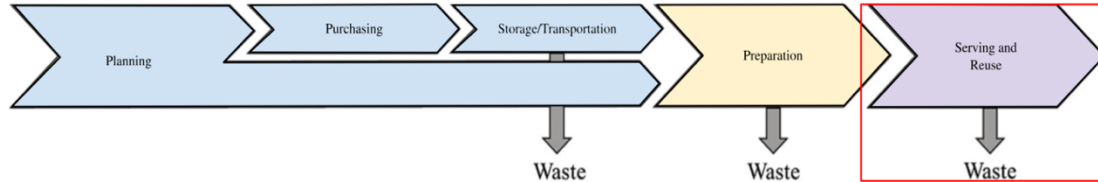
(follow up question if they say no and do not elaborate)

a. Can you elaborate on how those practices decrease food waste?

“Now I would like to ask about the benefits and risks associated with the circular practices that are used at [school/company] during serving and reuse. The same risks and benefit categories are listed.”

13) For each practice, describe any benefits.

14) For each practice, describe any risks.



Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably	
Serving/reuse: Methods used to give foods to consumers and methods used to reuse foods are when foods are prepared but then used as leftovers.	
Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)
Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)

VII. Conclusion

*“That was the last formal question, but (if time allows) **do you have any other thoughts about decreasing food waste through circular catering practices that could be useful to Dutch catering systems?***

Ok, then that concludes the interview, and I will turn off the recording. Thank you so much for taking the time for this interview. You have helped my research greatly, and I have enjoyed hearing your thoughts. If you would like the transcript, I will send it to you soon, and you have my contact information if you have any questions or further comments. Okay, have a nice rest of your day. Thank you, bye!”

Appendix 2.2 Informed Consent form



WUR – REC Non-Medical Research Informed Consent Risk-Benefit Analysis of Circular Economy Practices in Dutch School Catering

Olivia Rossman (olivia.rossman@wur.nl)

Thank you for your participation in this research study. Your participation is voluntary, and in order to participate, your written consent is required. Before you decide whether you want to participate, you will be given relevant information about the study and your participation in it. Please take your time to read this information and think of any questions you may have.

Study Background:

This interview is conducted for the Master's thesis in Food Quality Management of Olivia Rossman with the Food Quality and Design chair group at Wageningen University and Research. The thesis aims to gain an understanding of implementing circular catering practices in the Dutch school catering sector designed to decrease food waste within the Netherlands. This research aspires to contribute meaningful findings to the Dutch and EU goals for achieving a circular economy. The WUR Research Ethics Committee for non-medical research has approved this study as it meets the Netherlands Code of Ethics for research in the social and behavioural sciences involving human participants.

What is being asked of you as a participant?

If you agree to participate in this study, we will conduct an interview about your views and knowledge of catering practices used within Dutch school cafeterias/canteens. This interview will take approximately 45 minutes and will be conducted in English. I will voice-record the session for accurate data processing. You can choose not to participate in this study, and you can withdraw your participation at any time without providing any reasons and without any negative consequences. If there are questions you consider confidential, you may skip answering those questions.

What are the benefits of participating in this study?

By participating in this study, you will help researchers better understand the current knowledge of risks and benefits of circular economy practices in catering aimed to decrease food within the Dutch institutional school catering sector and lay a foundation for further research on circular catering practices. You will be informed about the overall findings. The gained insights will be used to develop recommendations on interventions, supporting programs, organisations, and policymakers for food waste reduction and circular economy within the Netherlands and the European Union.

How will your information be handled?

All of the data/information provided by you will be anonymised, meaning that your responses will be processed so that you as a participant are not identifiable. Your personal data will be kept confidential. Your name will be removed from the information you provide, and only a subject number will identify you during our data analysis. We will ensure that we do not include your personal data information in any of our reports/publications. Quotes from the interviews could be used within the text but will be chosen to ensure that the identity and personal data remains anonymous. The physical forms will be kept in the archive for 10 years and then destroyed to protect the personal data of the interviewees. Moreover, associated transcripts and raw audio recordings will be kept for 10 years and not published. You may obtain the transcript of the interview to review and gain access to the final thesis paper or publications.

What if I have questions about the study or change my mind?

If you have any questions regarding this study, you may contact Olivia Rossman via email: olivia.rossman@wur.nl or via phone: +31 6 39562196. You have the right to withdraw from the study at any time during your participation, without any penalty or loss of benefits to which you are otherwise entitled.

I consent to participating in this research and to the use of my personal data as described.

Name of the participant

Signature

Date

Appendix 2.3 Written Questionnaire

INTERVIEW: WRITTEN QUESTIONNAIRE

Risk-Benefit Analysis of Circular Economy Practices in Dutch Institutional School Catering

Dear Participant,

Please Read before starting the questionnaire:

Thank you for taking the time to share your thoughts with me for my thesis project; I really appreciate it. Before you start answering questions, I would like to give a brief overview of the interview along with a few logistical points.

My thesis topic is on circular economy practices that can be used in school catering systems to decrease food waste and how to compare the risks and benefits that are related. The purpose of this interview is to gain a deeper understanding of the Dutch school catering system and learn about circular catering practices to reduce food waste that are already occurring before food is served.

The main aims of the interview are to gain insights on the following:

- *The current practices that are used to decrease food waste before the food is served within Dutch school catering*
- *The potential benefits and risks of catering practices used to decrease food waste*

Make sure to read the additional text in between the questions because this information is required to answer the questions. If you have any questions before, during, or after answering the questions, please contact me via email: olivia.rossman@wur.nl or phone: +31 6 39562196.

Now you can answer the questions for the interview **online (typed answers)** and send it back once you have completed it to olivia.rossman@wur.nl.

Thank you,

Olivia Rossman

I. Introduction Questions

1) Can you please describe your current role in school catering

- How long have you had this role?

2) Could you describe how the catering system you work with is set up? (for example: who is responsible for the catering processes)

3) Can you describe the food services provided?

- What time(s) is the food available to students/staff?
- What meal types are available to them? (breakfast, snacks, lunch...)

- **What food products are available to them?** (sandwiches, hot meals, sweets, drinks)
- **To how many people do you approximately serve foods/meals per day?** (students/staff and how many)

Background information on Circular Catering Term: ‘circular catering’:

Description: Efforts within the catering sector to minimise, avoid, and recycle waste streams in the most sustainable.

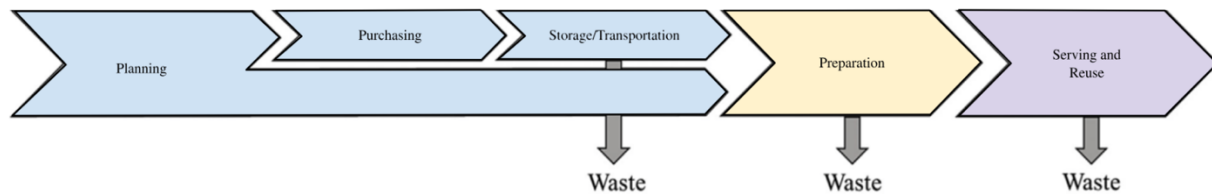
- Examples of circular catering practices: decrease animal protein consumption, reduce single-use plastics, increase use of return packaging, and decrease food waste.”

4) How would you describe ‘circular’ catering’?

- **What kind of practices are typical for circular catering in schools?**

II. Setting the scope

These next sections include more specific questions. In the image, the catering steps that are included in my project are shown. I am focusing on circular catering practices used to decrease food waste that are completed before consumption, so this includes planning, purchasing, storage, transportation, preparation, serving, and reuse of foods served at school canteens. I have grouped them into three sections, as indicated by the different colors. My project does not include consumption or any steps after that.

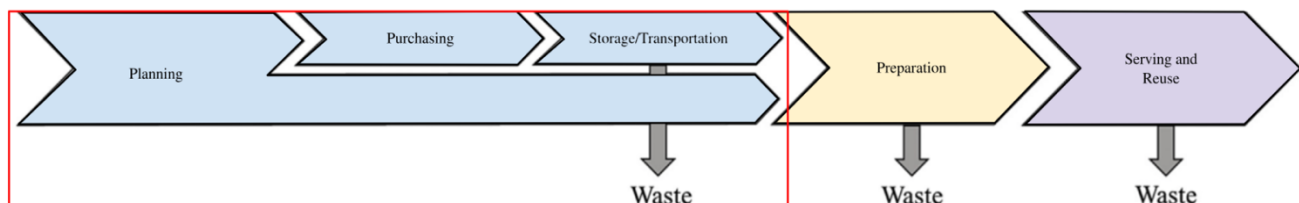


5) Does this figure align with your catering system?

- **Can you elaborate on the differences in your catering system?**

In the next set of questions, you are asked about circular catering practices that are currently being done within Dutch school catering in the blue, yellow, and purple sections, followed by benefits and risks attached to the practices.

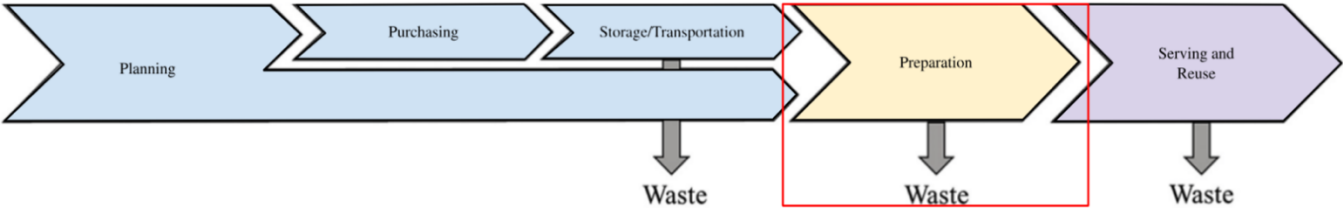
III. Planning, purchasing, storage/transportation



Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably	
Planning: This is done until the food is being prepared. Planning involves communications, such as communication between catering companies, other suppliers, and schools as well as other crucial steps like menu planning and planning order quantities, times, and foods.	
Purchasing: This includes where foods are being sourced, what is being purchased, and how much is being purchased.	
Storage/ transportation: This includes steps and environments (for example coolers, temperature control trucks) used and taken to get food from suppliers to the point of preparation/school.	
Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)
Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)

- 6) Can you think of any circular catering practices that are being used [at your school] to decrease food waste with the planning, purchasing, storage, and transportation steps specifically?
- Can you elaborate on why those practices decrease food waste?
- 7) Referencing the definition/categories of benefits, for each practice, describe any benefits.
- 8) Referencing the definition/categories of risks, for each practice, describe any risks.

IV. Preparation



Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably
Preparation: Steps taken to get food ready for serving the food; this can be done in a kitchen in the school or in a different location and then delivered in a ready-to-eat form at the school. This can be done in one way or in any combination. Food that is edible and wasted in this step is the focus of this question—for example eggshells are not food waste because they are not edible.

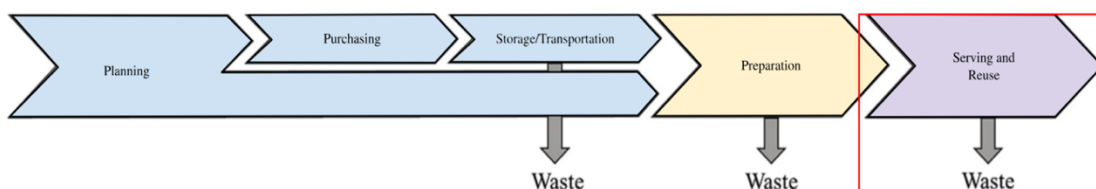
Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)
Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)

9) Can you think of any circular catering practices that are being used [at your school] to decrease food waste with the preparation of foods specifically?

- Can you elaborate on how those practices decrease food waste?

10) For each practice, describe any benefits.

11) For each practice, describe any risks.



V. Serving and Reusing

Circular Catering Practices: efforts within the catering system to minimise, avoid, and recycle food waste streams the most sustainably	
Serving/reuse: Methods used to give foods to consumers and methods used to reuse foods are when foods are prepared but then used as leftovers.	
Benefit: advantages or profits gained from something	-categories: economic (gain), regulatory (complies with laws), knowledge (increase), sustainable (better for environment), nutritional (increases), social (increase food security or jobs), availability (sufficient materials)
Risk: potential problems which might happen to something	-categories: Economic (loss), sustainability (worse for the environment), food safety (increased hazards-biological, chemical, physical), regulation (does not comply with laws), nutrition (decrease), social (decrease food security or jobs), availability (insufficient materials)

12) Can you think of any circular catering practices that are being used [at your school] to decrease food waste with the serving/reuse of foods specifically?

- **Can you elaborate on how those practices decrease food waste?**

13) For each practice, describe any benefits.

14) For each practice, describe any risks

VI. Conclusion

Do you have any other thoughts about decreasing food waste through circular catering practices that could be useful to Dutch catering systems?

Thank you so much for taking the time for this interview. You have greatly helped my research. You have my contact information if you have any questions or further comments. All the best!

Appendix 2.4 Example excel of qualitative analysis identification of circular CPs (RQ3)

Expert	Section of the supply chain	Unit of analysis (key words related to research questions)	Context analysis (parts of sentences that give meaning to the unit of analysis terms)	Core of meaning (grouping of context units based on their similarity, significance or relevance)	Category (grouping cores of meaning into a category; need to be aligned with the research aim)
	5 Preparation	looks nice	looks nice and then you umm sell everything OK because if you put there an ugly bread nobodys going to eat it	Preparing food in an appetizing way decreases food waste	Preparing food in an appetizing way decreases food waste

Appendix 2.5 Example excel of qualitative analysis identification of benefits (RQ4)

Expert	Unit of analysis (key words related to research questions)	Context analysis (parts of sentences that give meaning to the unit of analysis terms)	Core of meaning (grouping of context units based on their similarity, significance or relevance)	Category (grouping cores of meaning into a category; need to be aligned with the research aim)	Practice associated with benefit	Section of the supply chain
	2 Economic gain	Planning, purchasing and transportation/s storage: economic gain because we know what to buy.	planning meals in advance, planning according to ordering systems, and decreasing transportation are economic gains to decreasing food waste	economic gain	Using consumer preferences to plan meals for decreasing food waste	PPST

Appendix 3: Literature search broad benefits and risks

Broad benefits of identified circular catering practices within the literature search

Category	Identified Benefit (subcategory)	Benefit Description and associated Circular Practices (CP#)*
Economic	Supplies school with produce	•School garden (CP6) supply the school with produce to be used in meals and decreases costs needed to supply them in a different way ¹⁴
	Increases customer responsiveness	•Staff training and hiring qualified staff (CP10, CP11) increases customer responsiveness of the supply chain ²¹
	Increased kitchen efficiency	•Training staff, hiring qualified staff, and simplifying meals (CP10, CP11, CP19) decreases and smoothens the service time of assembly to serve lines which increases efficiency of the kitchen and saves money ^{17,21}
	Decreases labour costs	•AI (CP9) helps reduce the costs and risks of unavailability of labour ^{6,22}
	Decreases transportation costs	•Improving the relationship between catering companies and schools (CP14) decreases transaction and transportation costs ¹³
	Decreases costs	•Creating more sustainable menus(less meat) (CP17) can lower the costs of meals ^{12,20} •Practices (specifically included this benefit within in the text: CP1, CP2, CP3, CP8, CP22) that decrease food waste increases profit, increase in return on investment, and overall decrease of costs in the catering sector ^{3, 13, 16,17}
Social	Ethical pricing and wages	•Measuring food waste (CP1) can increase fair wages and ethical pricing ¹³
	Increased relationship building	•Improved meal planning (CP2) increases relationships and positive interactions between staff and students ¹⁷ •Using food sharing platforms (CP21) to provide canteen meals increased the social environment and interactions between students, teachers, parents, with the community ⁸
	Increases consumer happiness and meal satisfaction	•Providing tasting spoons for consumers to taste something before served (CP4), ensures it aligns with their flavour preferences ^{10, 16} •Pre-ordering and customer forecasting (CP8) increases meal satisfaction by taking consumer preferences into account ⁹ •Providing more vegetarian meals (CP17) increases some consumer satisfaction ¹
	Student involvement	•Adding a school garden (CP6) increases student involvement ¹⁴
	Positive impact on staff	•When staff influence decreasing food waste and training on food waste is done (CP10), typically there is a positive effect on personnel ²³

Category	Identified Benefit (subcategory)	Benefit Description and associated Circular Practices (CP#)*
	Increase food security	<ul style="list-style-type: none"> •AI (CP9)can increases food security by sensing if foods are bad before further use ²² •Using food sharing platforms (CP21) to use for student meals decrease child hunger by providing discounted meals for children ^{7, 8}
	Increased student comfort	<ul style="list-style-type: none"> •Changing the canteen environment (CP13) makes the students feel more comfortable and relaxed to waste less food⁹
	Increased positive attitudes towards sustainability	<ul style="list-style-type: none"> •Creating sustainable menus (CP17) led to an overall increased positive attitude to climate change policies in the catering supply chain¹² •Smaller serving sizes (CP18) resulted in stronger positive beliefs (attitudes) and personal norms regarding avoiding plate waste²⁴
	Increased student attendance/focus	<ul style="list-style-type: none"> •Using food sharing platforms (CP21) to provide canteen meals increased student attendance and focus ⁸
	Easy starting point (availability)	<ul style="list-style-type: none"> •Educational campaigns (CP3) can be an easy starting point for schools to implement to decrease food waste¹⁶
	School Flexibility (availability)	<ul style="list-style-type: none"> •Creating advisory councils (CP7) to decrease food waste at schools allows for increased practice specificity to be implemented ⁵
	Increased data availability (availability)	<ul style="list-style-type: none"> •AI and IoT (CP9) increases availability of seamless data to all participants in the value catering supply chain ⁶
	Availability of labor (availability)	<ul style="list-style-type: none"> •AI and IoT (CP9) mitigates labour shortages and makes it possible for more data/data analysis without increased labour ²²
	Easier measurements (availability)	<ul style="list-style-type: none"> •Simplifying meals (CP19) makes measuring food waste and carbon emissions used throughout the supply chain more available¹⁷
	Decreases allergy risks (safety)	<ul style="list-style-type: none"> •Menu planning (CP2) is closely related to dietary guidelines and meal diversity which decreases chemical hazards such as allergens⁹
	Increases food safety (safety)	<ul style="list-style-type: none"> •AI/IoT (CP9)can be used to sense if foods are bad and safe to eat²²
	Extending shelf life without decreasing food safety risk (safety)	<ul style="list-style-type: none"> •Freezing foods (CP16) extends shelf life safely without growing any microbiological growth and builds in the opportunity to optimise the utilisation of a food product for consumption.¹⁸

Category	Identified Benefit (subcategory)	Benefit Description and associated Circular Practices (CP#)*
	Increased nutritional value knowledge (nutrition)	•Measuring food waste (P1)can also be used to measure nutritional value of foods eaten and not eaten ¹⁸
	Increased nutritional variety(nutrition)	•Improved meal planning and using food sharing platforms (CP2, CP21) increases nutritional variety in school catering systems ⁹
	Increased nutritional foods eaten (nutrition)	•Improved meal planning (CP2), educational campaigns (CP3), school gardens (CP6), advisory councils (CP7), making more attractive meals/menus (CP15), and using food sharing platforms (CP21) increases nutritional intake of of vegetables/fruits, and positively influences dietary behaviour consumers ^{5,8,9,14,15,25}
	Increased ingredient cycle knowledge (knowledge)	•Improved meal planning (CP2) increases the catering sector with knowledge ingredient cycles ²³
	Increased nutritional knowledge (knowledge)	•Improved meal planning and educational campaigns (CP2, CP3) increases the cater sector and consumers with knowledge on nutritional topics such as dietary guidelines ⁹ , nutritional value of food, and obesity prevention ^{9,19}
	Increased knowledge of food systems(knowledge)	•Educational campaigns and school gardens (CP3, CP6) increase knowledge of food systems within the catering sector and consumers ^{9,14}
	Increased knowledge sustainability (knowledge)	•Educational campaigns and school gardens (CP3, CP6) increase knowledge, awareness and ability to decrease food waste ^{3,4,9,17,23,24,26,27}
Environment	Reduces overall carbon footprint	<ul style="list-style-type: none"> •Reducing food waste with long term continuous improvement (CP1) reduces emissions of greenhouse gas and overall carbon footprint of the catering sector ^{11,13,16,23} •Improving catering management (CP12) and improving the relationships between catering companies and schools (CP14) can make the amount of deliveries more energy efficient which decreases CO₂ emissions ^{13,20} •Overall environmental (greenhouse gas emissions) impact is lower when using sustainable menus (such as vegetarian) (CP17) ^{1,12,18,20}
	Improves resource utilisation	<ul style="list-style-type: none"> •Measuring food waste (CP1), improving meal planning (PC2), improving catering management (P12), and simplifying meals/menus (P19) improves resource utilisation such as water, energy, land, and nutrients of the food ^{16,17,18} and prevents food waste from spoilage ^{3,23} •The creation of advisory boards (CP7) and increased attractiveness of meals (CP15) to decrease food waste decreased the amount of vegetables wasted at the school ⁵ •Improved relationships between caterers and schools (CP14) decreases the amount of food waste by adjusting quantities of foods ordered and prepared along the supply chain ^{9,13,19}
	Decreased plate waste	<ul style="list-style-type: none"> •Plate waste can be decreased by meal planning improvements (CP2), using portion control/smaller portions (CP18), using personalised meals ^{17,19,25}, and when seasonality and external factors such as day of the week and holidays are taken into account ³ •Educational campaigns (CP3) decreased plate food waste in schools ^{14,15,16,24,27,28} •Using tasting spoons (CP4) prevents plate waste by allowing consumers to make informed choices about the food they could take ^{10,16} •Increasing attractiveness of meals (CP15) and serving popular vegetarian meals (CP17) decreased plate waste ^{1,9,25}

Category	Identified Benefit (subcategory)	Benefit Description and associated Circular Practices (CP#)*
	Facilitates awareness of food waste	<ul style="list-style-type: none"> •Educational campaigns (CP3) facilitates long term habits to decrease food waste and decrease food waste in other than in the canteen (such as at home or in other public areas) ^{14, 17, 19, 23, 26, 27, 28} •School gardens (CP6) increases sustainability awareness to youth groups ¹⁴ •Training staff (CP10) to decrease food waste increases food waste awareness among kitchen staff ¹⁹ •Smaller serving sizes (CP18) resulted in positive beliefs (attitudes) and stronger personal norms regarding avoiding plate waste. ^{24, 27}
	Decreased food overproduction of prepared foods	<ul style="list-style-type: none"> •Customer forecasting and pre-ordering (CP8), use of AI and IoT (CP9), and removing buffet serving style (CP20) decreases food overproduction to decrease preparation, serving, and plate food waste ^{6, 9, 16, 17, 19, 22}
	Serving waste can be valorized	<ul style="list-style-type: none"> •Freezing foods (CP16) can be used to decrease food waste before and after preparation to safely store foods ^{3, 18} •Reusing leftovers for next meals (CP22) valorizes waste as a strategy against overproduction ^{3, 25}

(¹Arrazat et al., 2024; ²Balzaretti et al., 2020; ³Betz et al., 2015; ⁴Browne et al., 2023; ⁵Byker Shanks et al., 2023; ⁶Chapman et al., 2022; ⁷de Almeida Oroski & da Silva, 2022; ⁸Deavin et al., 2018; ⁹Derqui et al., 2018; ¹⁰Economou et al., 2024; ¹¹Eriksson et al., 2019; ¹²Eustachio Colombo et al., 2020; ¹³Gokarn & Choudhary; ¹⁴Lee et al., 2021; ¹⁵Prescott et al., 2019; ¹⁶Malefors et al., 2022; ¹⁷Marais et al., 2017; ¹⁸Martindale, 2016; ¹⁹Moraes et al., 2021; ²⁰Saxe et al., 2019; ²¹Sel et al., 2017; ²²Sharma et al., 2022; ²³Silvennoinen et al., 2019; ²⁴Sullivan et al., 2021; ²⁵Sundin et al., 2023; ²⁶Vidal-Mones et al., 2022; ²⁷Wang et al., 2024; ²⁸Wilkie et al., 2015)

Broad risks of identified circular catering practices within the literature search

Category	Identified Risk	Risk Description and associated Circular Practices (P#)*
Economic	Higher wages and more work	<ul style="list-style-type: none"> Higher wages and more work required for methods to measure food waste (P1), conduct educational campaigns (P3), improve relationships between caterers and schools (P14), make menu changes (P15, P17), remove buffet style of serving (P20) ^{3, 9, 10, 13, 19, 23, 24}
	No profitability	<ul style="list-style-type: none"> There is a viewpoint that argues that measuring food waste does not have an impact on profitability⁹
	Economic investment	<ul style="list-style-type: none"> Investment in tools and methods to measure food waste (P1), make school gardens (P6), train staff (P10), hire qualified staff (P11), use AI/IoT technologies ^{14, 21, 22, 23} Requires investments to create and implement educational campaigns(P3) (including motivations), develop and expand regulations (P5)^{10, 13}
Social	Age/student dependent success	<ul style="list-style-type: none"> Educational campaigns (P3), increasing the attractiveness of menus (P15), and portion control methods (P18) affects age groups differently as changes in attitudes does not always translate to behaviour, so the success of decreasing food waste and learning is dependent of age and the personal factors students ^{9, 16, 17, 24, 27}
	Practice backlash	<ul style="list-style-type: none"> Educational campaigns (P3) can receive some backlash that the cafeteria is not where students learn ⁹ Portion control measures (P18) could be misinterpreted by the students as a way to restrict their intake ²⁵
	Unethical Practices	<ul style="list-style-type: none"> The use of AI and IoT (P9) can use unethical practices and lead to intellectual property issues ²²
	Labour reduction	<ul style="list-style-type: none"> The use of AI and IoT (P9) can lead to labour reduction within the catering sector ²²
	Resistance to change	<ul style="list-style-type: none"> When creating more sustainable menus (P17) some people showed resistance suggested changes, especially when dynamics changed from existing¹²
	Lack of methods and effort to implement (availability)	<ul style="list-style-type: none"> No current common practice for measuring food waste (P1) in school canteens to support waste-reducing efforts¹¹ There can be problems measuring food waste (P1) consistently as well as incomplete measurements occur within the school catering sector ^{3, 16, 23} Long term, educational campaigns (P3) are not as impactful overtime ^{4, 14, 15, 23} Changing regulations (P5) require resources such as time, effort, staff, checks ⁹ Improving meal planning (P2) and creating more attractive menus (P15) requires staff motivation and observation ^{3, 9, 17, 23, 24, 25} Changing Regulations (P5) are difficult to implement ¹³ Changing canteen environment takes additional effort ⁹ Removing buffet serving style (P20) is requires more effort and is time consuming for staff which requires strong motivation from the staff¹⁹ Conducting customer forecasting and pre-ordering requires changes in routines and systems, which requires higher effort and motivation of staff ^{16, 17} Using food sharing platforms (P21) requires extensive communication between stakeholders which takes a lot of effort ⁷

Category	Identified Risk	Risk Description and associated Circular Practices (P#)*
	Lack of commitment (availability)	<ul style="list-style-type: none"> •Strong commitment is required to measure food waste (P1), conduct educational campaigns (P3), and use portion control (P18) especially for long term measurements and follow up is required ^{3, 19, 21, 23} •When implementing educational campaigns (P3), it is also important to also incorporate commitments such as motivations (prizes)¹⁰ •Changing regulations (P5) require long term commitment ⁹ •Adding a school garden (P6) and creating advisory councils require a lot of effort, time, and volunteers ^{1, 5} •Added communication to improve relationships between caterers and schools (P14) and improving catering management (P12) takes time, effort, and tools to work well for all stakeholders involved ^{13, 19, 23}, especially in larger supply chains ⁹ •Removing buffet serving style (P20) is requires more effort and is time consuming for staff which requires strong commitment from the staff¹⁹ •Using food sharing platforms requires a lot of communication between stakeholders which takes a lot of commitment ⁷
	Staff training lacking (availability)	<ul style="list-style-type: none"> •Methods to measure food waste (P1) require staff training ^{3, 16, 23}
	Hard relationships and communications (availability)	<ul style="list-style-type: none"> •Changes in catering contracts when improving meal planning (P2) can an lead to difficult relationships ¹⁷ •Communications on portion limitations must be very clear when using portion control measures (P18) to avoid misunderstandings and ensure the satiety of students
	Additional knowledge required to implement practice (knowledge)	<ul style="list-style-type: none"> •Staff need to know how to analyse food waste data (P1) when there are day-day and week-week variations ³ •Staff need to know how to properly separate measurements (P1) between different outlets (kitchen, serving, plate) ²³ •Adding a school garden (P6) requires a strong knowledge of food systems and sustainability ¹⁴ •Improving relationships between caterers and schools (P14) requires parties to communicate information clearly, which can be difficult in large supply chains ¹⁹ •Staff need additional knowledge and expertise to be able to use leftovers and reinvent recipes (P22) ¹⁹
	Lack of knowledge (knowledge)	<ul style="list-style-type: none"> •There is a lack of knowledge between links of catering chain make it difficult to change management (P12) ²⁰ •Lack of clear knowledge or guidelines applicable to school catering to create more sustainable menus (P17)¹⁸ •Students lack knowledge of serving sizes when serving themselves is used as an effort to decrease portions (P18) because students' perceptions of the portion sizes were contradicted by their actual consumption ¹⁷
	Unknown consequences (knowledge)	<ul style="list-style-type: none"> •Increasing the use of data (P9) will change the current status quo in various steps of the food value chain, and consequences and problems with change are unknown ⁶
	Incorrect perception (knowledge)	<ul style="list-style-type: none"> •When students serve themselves in an effort to decrease portions (P18), students' perceptions of the portion sizes were contradicted by their actual consumption ¹⁷
	Food safety risk (safety)	<ul style="list-style-type: none"> •Increased biological food safety risk for reusing foods on sharing platforms (P21) if not stored properly ⁷

Category	Identified Risk	Risk Description and associated Circular Practices (P#)*
	Lack of regulation (regulatory)	<ul style="list-style-type: none"> ●The lack of common standards for measuring food waste (P1) results in difficulties to implement food waste in schools catering sectors ^{11, 16,18} ●There is a lack of regulations on using food sharing platforms (P21) ⁷
	Leftover Regulations (regulatory)	<ul style="list-style-type: none"> ●Leftovers cannot be reused (P22) under certain considerations of legislation for food safety reasons ³
	Decreased food consumption (nutrition)	<ul style="list-style-type: none"> ●Educational campaigns (P3), decreased portion sizes (P18), and making more simple meals (more limited options) decrease food consumption which risks consumers not meeting nutritional needs ^{2, 14, 17, 25} ●If unpopular dishes (P2, P15) are served and left not taken nutritional values will not be made²⁵
	Decreased nutritional value (nutrition)	<ul style="list-style-type: none"> ●Some vegetarian meals (P17) are less nutritious than non-vegetarian meals¹ ●Donated options (P21) were sometimes not viewed as healthy⁸
Environment	Food waste not decreased or is increased through the methods implemented	<ul style="list-style-type: none"> ●When food waste is measured but corrective actions are not taken, this method does not decrease food waste¹³ ●There is a variation of success of educational campaigns to decrease food waste, and did not decrease food waste in serving or kitchen sections ^{16, 24} ●There is a risk that forecasting methods or pre-ordering (P8) is incorrect when people do not act as expected, serving waste is increased¹⁷ ●Some vegetarian/more sustainable meals (P17) are unpopular and increase food waste ^{18,25} ●Self serving to offer personalised portion sizes (P18) can increase food waste in popular meals because students serve themselves too much ²⁵ ●When meals are simplified (P19), students have more limited choices which could increase plate waste ¹⁷

(¹Arrazat et al., 2024; ²Balzaretti et al., 2020; ³Betz et al., 2015; ⁴Browne et al., 2023; ⁵Byker Shanks et al., 2023; ⁶Chapman et al., 2022; ⁷de Almeida Oroski & da Silva, 2022; ⁸Deavin et al., 2018; ⁹Derqui et al., 2018; ¹⁰Economou et al., 2024; ¹¹Eriksson et al., 2019; ¹²Eustachio Colombo et al., 2020; ¹³Gokarn & Choudhary; ¹⁴Lee et al., 2021; ¹⁵Prescott et al., 2019; ¹⁶Malefors et al., 2022; ¹⁷Marais et al., 2017; ¹⁸Martindale, 2016; ¹⁹Moraes et al., 2021; ²⁰Saxe et al., 2019; ²¹Sel et al., 2017; ²²Sharma et al., 2022; ²³Silvennoinen et al., 2019; ²⁴Sullivan et al., 2021; ²⁵Sundin et al., 2023; ²⁶Vidal-Mones et al., 2022; ²⁷Wang et al., 2024; ²⁸Wilkie et al., 2015)