CIRCULAR ECONOMY STRATEGIES FOR REDUCING FOOD WASTE IN SCHOOLS: A SYSTEMATIC LITERATURE REVIEW

Juta Deksne[1], Lienite Litavniece[2], Jelena Lonska[3], Anda Zvaigzne[4]

[1] PhD student, Rezekne Academy of Technologies, Rezekne, Latvia, e-mail: Juta.Deksne@rta.lv

[2] Dr. oec., associated professor, leading researcher, Rezekne Academy of Technologies, Rezekne, Latvia, e-mail: Lienite.Litavniece@rta.lv

[3] Dr. oec., associated professor, leading researcher, Rezekne Academy of Technologies, Rezekne, Latvia, e-mail: Jelena.Lonska@rta.lv

[4] Dr. oec., associated professor, leading researcher, Rezekne Academy of Technologies, Rezekne, Latvia, e-mail: Anda.Zvaigzne@rta.lv

Abstract.

Purpose and aim of the study: *As the transition to a circular economy (CE) and the reduction of food waste is a priority strategic goal for policy planning at global and European Union (EU) level, but food waste in catering has become a major sustainability issue, the aim of the paper is to identify CE strategies to reducing food waste in schools based on a systematic literature review.*

Design / Methodology / Approach: *The research employed qualitative methods: five-step systematic literature review methodology by Denyer & Tranfield, (2009), analysis and synthesis, as well as the monographic method. The literature was selected using the databases Google Scholar, MDPI, ScienceDirect and Scopus.*

Main Findings: *Based on the systematic literature review, approaches for implementing CE strategies to reduce food waste in school canteens were discovered.*

Originality: *This study provides a new perspective on the implementation of CE "R strategies" to reduce food waste in schools.*

Implications: *The results of the study can be a basis for school and canteen administration to implement CE policies and waste management practices that will promote responsible food consumption and support sustainable food consumption and waste reduction strategies, and create added value for school canteens, the environment and society in general.*

Keywords: *circular economy, R strategies, food waste, sustainability.*

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Introduction

Since 2011, questions about zero-waste food policy in the EU Member States were increasingly considered on the EU agenda at all political levels. In 2015, the group of Ministers of Finance and Governors of Central Banks of G20 Countries (hereinafter G20) announced that "the reduction of food

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losses and wastes is a good goal for G20 collective actions" (European Court of Auditors, 2016), and the UN General Assemblies adopted the Sustainable Development Programme for 2030 (or Agenda 2030), which includes 17 sustainable development goals (hereinafter SDGs) and 169 related goals that should be achieved by 2030. In relation to the author's theme, Goal 12 envisages responsible consumption and production - halving the amount of global food wastes per capita at the retailer and consumer level, as well as reducing food losses in production and supply chains, which can help to ensure food security and move towards a resource-efficient economy (UNGA, 2015).

Food waste from out-of-home dining has become a major sustainability issue (Dhir et al., 2020), therefore, hospitality businesses, including school canteens, must follow responsible practices and consider sustainable production and consumption behaviours to reduce food wastes (Camilleri, 2021). It has been found that food service businesses can pursue a number of responsible practices by implementing preventative measures and recycling practices to limit food losses and waste, as well as reduce environmental impacts (Camilleri, 2021; Lopez et al., 2019). That is why the food industry can become one of the main areas to apply the CE model, yet the current level of CE implementation in the food system makes it difficult to combine theory and practice (Fassio & Tecco, 2019).

CE is currently being popularized all over the world. Issues such as food security and environmental impacts such as resource depletion and greenhouse gas emissions associated with food wastes are the focus of local, national, and European policy makers, as well as international organizations and researchers from various sectors (Schanes et al., 2018).

The transition to a CE requires innovative solutions in all value chains (Holzer et al., 2022), and food is one of the main CE product value chains. The CE concept aims to create a food system that ensures that food does not create waste. (Ellen MacArthur Foundation, 2022).

Catering in schools is essential in shaping students' eating habits and attitudes toward food (García-Herrero et al., 2019; 2021), so it is important for school management to plan and organize the catering process in such a way that it promotes responsible food consumption and supports sustainable food consumption and waste reduction strategies.

Therefore, the aim of the research is to identify the CE strategies to reducing food waste at schools based on a systematic literature review.

The tasks of the research are to perform a literature analysis on CE strategies in reducing food waste and to identify how they could be used in the catering process in schools.

This research used the five-step systematic literature review method by Denyer & Tranfield (2009), analysis, and synthesis, as well as the monographic method.

Research results and discussion

To achieve the goal, the present research was carried out using a five-step systematic literature review methodology (Denyer & Tranfield, 2009): 1) question formulation; 2) locating studies; 3) study selection and evaluation; 4) analysis and synthesis; 5) reporting and using the results.

The research question is as follows: how can a CE approach be used to reduce food waste in schools?

Using the keywords "circular economy" and the name of the relevant R strategy, "in school catering", the literature was selected using the databases Google Scholar, MDPI, ScienceDirect and Scopus.

Based on the titles of the papers, abstracts, keywords in the text, the most relevant papers were selected, from which those that answered the research question were chosen and analysed. The results are reported below.

The CE is a new concept that emphasizes various strategies (e.g., reduce, reuse and recycle) to decouple resource use from economic growth, reduce wastes and emissions, and keep the highest utility throughout the product life cycle (Holzer et al., 2022). Various CE strategies can be used to prevent excessive and rapid environmental degradation and social inequality, both locally and globally. The main purpose of the CE is to eliminate waste. If waste is unavoidable, it should be adequately controlled to be safe for human health and the environment (Khaw-ngern et al., 2021).

In the scientific literature, the main fundamental principles of the CE on which CE strategies are based are "reduce", "reuse" and "recycle", which are defined as the "3Rs" (Ghisellini et al., 2016; Liu et al., 2017). But since the food supply chain plays a vital role in increasing economic, environmental, and social sustainability issues, focusing on the 3Rs is no longer enough in the context of the CE (Vlajic et al., 2021), and over time they have evolved to the framework of 10R strategies (Table 1), described by the authors Holzer et al. (2022) and Potting et al. (2017).

The authors analysed the strategies indicated in Table 1 in reverse order from bottom to top, because according to the authors Holzer et al. (2022) and Potting et al. (2017) studies, the strategies shown in Table 1 are based on the waste hierarchy of the waste framework directive (European Commission, 2008), which was adopted to reduce environmental impact by increasing the extent of circularity, thereby strategies that promote sustainable product production and use (e.g., a product as a service, product

sharing) are preferred over product life extension, as the need for natural resources is determined. Based on priorities set in the food waste hierarchy, prevention should be regarded as the first strategy against food waste, considering re-use or recycling of food waste only where prevention is not possible (Cicatiello et al., 2020).

Table 1 The 10R Framework (Holzer et al., 2022; Potting et al., 2017)

Strategies		**Explanation**
Smarter product use and manufacture	R1 Refuse	Make the product redundant by abandoning the function or by performing the same function by a radically different product
	R2 Rethink	Make product use more intensive (e.g., through products or by placing multi-functional products on the market)
	R3 Reduce	Increase efficiency in the manufacture or use of products by consuming less natural resources and materials
Extend the lifespan of the product and its parts	R4 Re-use	Re-use by another consumer of a discarded product that is still in good condition and performs the original function
	R5 Repair	Repair and maintenance of defective products so they could be used for their original function
	R6 Refurbish	Restore an old product and bring it up to date
	R7 Remanufacture	Use parts of a discarded product in a new product to perform the same function
	R8 Repurpose	Use a discarded product or its parts in a new product with different function
Useful application of materials	R9 Recycle	Process materials to have the same (high grade) or lower (low grade) quality
	R10 Recover	Incineration of materials for energy recovery

The useful applications of materials. This group's strategies for recycling and recovery are more concerned with the recycling of materials and their incineration with energy recovery; however, they can be attributed to the catering sector like recovering and recycling wasted food through donation, salvaging, processing, industrial reuse and composting (United States Environmental Protection Agency, 2016; 2023).

R10 Recover. The scenarios of this strategy are very modern and technological, but the authors believe that in the future they could also be used in school canteens because FW is a carbon-rich waste stream that could be used for the recovery of a wide range of energy and materials, from fuels/energy to chemical components to bio-plastics (Santagata et al., 2021), for example, use of microbial fuel cells (MFCs) due to their ideal approach in the generation of electricity and parallel treatment of organic food wastes. The MFCs are significant as an innovative approach using microorganisms and oxidizing organic food wastes into bioelectricity

(Kumar et al., 2022a). The so-generated commodities show various benefits such as reduced environmental impacts, deriving from the avoided disposal and the avoided extraction of natural resources, and the reduced economic cost of FW as a feedstock (Santagata et al., 2021).

R9 Recycle. This includes options such as recycling food wastes for animal feed (Ali, 2020), using a traditional technology (composting) and a radical innovative one (insects as feed) (Borrello et al., 2017). The recycling of food by-products, which can also be used in animal and human nutrition, is also mentioned in the context of this strategy (Jackowski et al., 2020).

Extend the lifespan of the product and its parts. The purpose of this group's strategies is to retain goods and their parts in the economy as long as possible, while at the same time maintaining or improving their value (Morseletto, 2020). The European Parliament (2016) underlines that the longer life of products means that it is necessary to take appropriate measures to combat planned obsolescence and increase consumer rights by improving product information. The authors believe that to effectively implement these strategies, it is required to strengthen the waste management policy of school canteens, where FW is not thrown away, but collected and transferred to implement other strategies.

R8 Repurpose. This strategy can be applied using food waste and by-products as a resource (Kumar et al., 2022b), for example, by using tallow for biodiesel production, capturing methane produced in the onsite wastewater treatment system for electricity generation, using tallow to generate the remaining electricity needs and using biomass for thermal energy generation (Colley et al., 2020), or using food waste to produce building blocks for use in bioplastic production (Visco et al., 2022).

R7 Remanufacture. This strategy is intimately linked with the revalorization of by-products for the generation of high-revenue bioactive compounds (Montone et al., 2021).

R6 Refurbish. Literally restoring spoiled food and bringing it up to date is impossible, but this strategy can be applied as the management of food products that have not been served for various causes and are thus destined to be discarded and moved to landfill, thereby representing only a cost (Giuseppe et al., 2014).

R5 Repair. Food repair is a relational practice that links an eating body with organic matters, producers and farmers, soils, supermarkets, modes of preservation and packaging, as well as kitchen technologies, food preparation, cooks, and other eaters (Abrahamsson, 2019). The author Abrahamsson (2019) articulates the various, different skills and resources that are used when food gets repaired with the following examples: individuals collecting and eating discarded food from dumpsters; collective dinners to eat foods that have expired their due date; and people growing

and eating food in communal gardens in a city. In the context of school canteens, this strategy could be applied by donating uneaten food, or food that has expired but has not yet been spoiled.

R4 Re-use. In scientific literature, this strategy is mentioned in context of food management practices such as "food freezing" or "reuse leftovers for new recipes" (Principato et al., 2022), also valorise food losses into animal feed to contribute to a reduced environmental and climate footprint of animal products and food waste avoidance (Pinotti et al., 2021).

Smarter product use and manufacture. From the CE point of view, these are the most circular strategies. The food industry is under growing pressure to produce high-quality and minimally processed foods by using sustainable approaches and ingredients, as well as increasing demands to replace animal products with plant-based products (Mahony & van Sinderen, 2022). Besides, the challenge of persuading people to change their eating habits to more environmentally friendly food consumption patterns become more and more relevant (Vermeir et al., 2020); therefore, it is necessary to improve the availability and price of sustainable food, as well as to promote a healthy and sustainable diet among consumers. The key elements are improving consumer information, strengthening sustainable food procurement, and promoting the introduction of fiscal measures supporting sustainable food consumption (European Commission, 2023).

R3 Reduce. Strategic opportunities to reduce food loss and waste, sustainable use of resources in the food supply chain (Iagăru et al., 2023; Lemaire & Limbourg, 2019; Reynolds et al., 2019) and reduction in the carbon footprint throughout the chain of food supply (Bhatia et al., 2023).

R2 Rethink. Rethink is mainly focused on rethinking the behaviour and perception of the CE by consumers and organizations (Sitadewi et al., 2021). Rethink comes first as individuals consider and question their habits (Mak et al., 2021). It has been studied that educational, skills-based school interventions to decrease food waste by encouraging schoolchildren to be more involved at home in choosing and/or preparing food to take to school can lead to food waste behaviour change to the good side (Boulet et al., 2022).

R1 Refuse. This strategy can be applied by excluding from the menu recipes that children do not like (Pagliarino et al., 2021). Most of the establishments do not have menu alternatives, consumers can only decide whether to order the food offered. In order to increase the amount of food actually eaten, it would be desirable to remove less-liked dishes from school catering menus (Tóth et al., 2023), and it is also highly recommended to periodically review the menus and not include in them the foods that schoolchildren do not want (Ellison et al., 2019), because school menus

should be based not only on the requirements of the relevant legislation but also on modern students' understanding of nutrition (Lonska et al., 2022).

The results show that “R strategies” in transition to a CE are the most widely described strategies in the scientific literature (Khan & Haleem, 2021), and they can be widely used in various industries, including the food sector (Morseletto, 2020; Khaw-ngern et al., 2021).

Conclusions and suggestions

As the transition to a CE and the reduction of food waste is a priority strategic objective in policy planning on the global and EU scale, and food waste in catering has become a major sustainability issue, school catering businesses could implement responsible practices by introducing preventive measures and recycling practices to reduce food losses and wastes, and the impact on the environment.

The systematic literature review results show CE “R strategies” implementation approaches to reducing food wastes at school canteens.

The results of the research could serve as a basis for school and canteen administration to implement CE policies and waste management practices that will promote responsible food consumption and support sustainable food consumption and waste reduction strategies, and create added value for school canteens, the environment and society in general.

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