MRER
MALTA REVIEW OF EDUCATIONAL RESEARCH

Volume 20, No. 1, 53-73
Faculty of Education©, UM, 2026

Impact of Nutrition Education on Dietary Practices and Food Waste in Moroccan Adolescents

Soukaina Ben Angua*, Ghizlane Benaddi *, Anouar Rafik*, Mohammed Elayachi*, Abdellah El Habazi* And Rekia Belahsen* **

*Laboratory of Anthropogenetics, Biotechnologies, and Health, Department of Biology, Faculty of Sciences, Chouaib Doukkali University, El Jadida 24000, Morocco

**rekiabelahsen@gmail.com (Corresponding author)

Abstract: The Mediterranean diet is a sustainable dietary model, but its adoption remains limited among adolescents in Morocco. Food waste, particularly of certain staple foods of this diet, is common within this population. This study aimed to analyse dietary habits and evaluate the impact of an educational intervention on food waste among school-aged adolescents. Data on dietary habits, adoption of Mediterranean diet and frequency of food waste were collected from a sample of 200 school-aged Moroccan adolescents (40% boys, 60% girls). Awareness-raising workshops were then organised to encourage better practices. The analysis revealed that only 40% of adolescents adopted the Mediterranean diet and that 60% frequently wasted food, primarily bread (43.7%) and fruits and vegetables. The wasting of food took place several times a week, often due to lack of appetite, or overly large portions. Following the educational intervention, a significant decrease in food waste was observed for all food categories, with a particularly marked reduction for bread (from 150 to 10 g/student/day) and a complete elimination of dairy waste (from 90 to 0 g/student/day).

Conclusion: These results demonstrate that targeted educational interventions can effectively reduce food waste and promote sustainable eating habits among adolescents.

Keywords: Mediterranean diet, adolescents, food waste, nutrition education, Morocco

Introduction

Sustainable agriculture and food security currently represent two of the most pressing and complex challenges for the future health of our planet and the stability of its socio-economic systems. According to the FAO, an estimated **60%** increase in food production will be necessary by the year 2050 to meet the basic nutritional needs of the world's rapidly expanding population (Alexandratos and Bruinsma, 2012). Faced with ongoing population growth, rapid urbanisation, changing dietary habits -- including a marked preference for processed foods and animal-based proteins -- and the increasing scarcity of vital natural and financial resources, it is now imperative to produce more while strictly respecting the fundamental principles of sustainable development (FAO, 2017; Global Panel, 2017). This paradox of needing higher yields amidst dwindling resources could, however, be significantly mitigated by a collective shift toward more conscious eating habits and a drastic, systematic reduction in food waste (Rockström et al., 2025).

Indeed, the pressure on land and water resources is exacerbated by the fact that there are foods produced, but which never reach the human stomach, an increasingly untenable situation in a world with limited resources (Kummu et al., 2012). So much so, reducing agricultural losses and food waste has emerged as a key priority for achieving the United Nations' Sustainable Development Goals (SDGs), specifically Goal 12.3 which aims to halve per capita global food waste through sustainable food systems (FAO, 2019).

Food sustainability refers to a comprehensive mode of production and consumption that respects the environment, protects human health, ensures social well-being, and promotes economic equity. It encourages the consumption of local, seasonal and minimally processed foods, while strictly limiting waste at every point of the cycle. In this regard, the Mediterranean diet is recognised as an exemplary model for its balance of biodiversity and nutrition (Hachem et al., 2016; Rockström et al., 2025). Adherence to a sustainable Mediterranean diet appears to be a protective factor against food waste. A study conducted with Italian students showed that individuals with a diet closer to the Mediterranean model adopted more sustainable behaviours, including better management of leftovers and a reduction in waste (Nucci et al., 2025). However, evidence also suggests that adherence to the Mediterranean diet among adolescents is generally low to moderate, with only a minority achieving optimal adherence (approximately 10–20%) (Di Nucci et

al., 2025). This finding is consistent with those of previous systematic reviews indicating that optimal adherence is achieved in less than 25% of children and adolescents even in Mediterranean regions (Iaccarino Idelson et al., 2017).

Reducing food waste remains a key criterion for sustainable food systems; it is a phenomenon that occurs at several levels of the food supply chain, from initial production to final household consumption (Ishangulyyev, 2019; HLPE, 2014). Each year, nearly one-third of all food intended for human consumption is lost or wasted along supply chains at the local, national, regional, and global levels. This staggering inefficiency compromises the overall sustainability of food systems and severely limits their capacity to ensure long-term food and nutrition security for all (HLPE, 2014). According to a landmark FAO report published in 2013, between 30 and 50% of the total food produced worldwide is simply thrown away. The breakdown of these losses revealed a crisis across all food groups, with perishable items being the most vulnerable. Food waste occurs at every single stage of the supply chain: during and after harvest, before reaching retail outlets, and directly by consumers and retailers in homes and markets. This waste also has a considerable environmental impact, as food waste buried in landfills generates methane, a greenhouse gas much more potent than carbon dioxide (West et al., 2014).

This systemic failure represents a loss of natural resources in terms of land, water and inputs and labour invested in the process, contributing significantly to unnecessary greenhouse gas emissions (Varjani et al., 2024). Therefore, food waste must be addressed from the perspective of responsible natural resource management and food system sustainability, by taking strategic action throughout the entire chain, from production and distribution to consumption and eventual nutrient recovery (Agya, 2025; de Souza et al., 2025; Wood et al., 2019). Education bridges the gap between scientific awareness and behavioural change, fostering a sense of global citizenship among learners. In this context, nutrition education can play a fundamental and transformative role in transmitting the essential knowledge, practical skills and ethical attitudes necessary for adopting healthy, responsible and sustainable eating habits (Carvalho & Martins, 2024).

Adolescence is a crucial period for the acquisition of healthy eating habits. Several studies have highlighted that habits acquired at this age, particularly regarding food consumption and management, can persist into adulthood, thus justifying the importance of targeting this population in food waste

reduction strategies (Mondéjar-Jiménez et al., 2016). Furthermore, by educating young people, this targets the demographic group that will shape tomorrow's consumption patterns and political decisions.

With this in mind, the present study implemented a comprehensive educational programme specifically designed for Moroccan adolescents. This programme incorporated intensive training sessions detailing the devastating consequences of food waste on the environment, the economy and our dwindling natural resources, while demonstrating the powerful moral reality that every meal thrown away today is one less meal available for future generations. The pedagogical approach focused on interactive learning to ensure that students internalised the ecological cost of their dietary choices.

Although several studies have addressed food waste and the adoption of healthy eating habits among adolescents, few have examined school-based interventions that combine a sustainable food model, such as the Moroccan Mediterranean diet, with practical tools to reduce food waste within families and local communities. The objective of this study was therefore to encourage school-aged adolescents to adopt healthy and sustainable eating habits inspired by the Moroccan Mediterranean diet and, above all, to provide them with the tools and motivation needed to reduce food waste in their families and local communities, so that they can become ambassadors for a more resilient and equitable food system.

Methodology

This prospective observational study is part of a larger research project designed to evaluate the impact of an educational intervention on multiple variables, including diet quality, adherence to the Mediterranean diet and awareness of food waste among high school students.

Study sample

The study sample included 200 students of both sexes, aged 13 to 18 years, attending public and private high schools in both rural and urban areas at Berrechid city in Morrocco. Participants were purposively selected to ensure a representative sample reflecting diverse socioeconomic, cultural and geographic backgrounds, allowing for a comprehensive understanding of the factors influencing dietary habits and food waste behaviours. Sociodemographic and socioeconomic information was collected to explore

potential correlations with food practices and identify groups that may benefit most from targeted interventions.

Inclusion criteria were enrollment in the school and parental authorisation. Students who did not obtain parental consent, or were absent during key data collection periods were excluded. All participants and their parents were fully informed about the objectives, procedures and confidentiality measures of the study.

Study procedure

This study aimed to assess the short-term impact on a group of adolescent students of a healthy diet and food waste-related education intervention. The intervention sought to promote healthy eating habits, inspired by the Moroccan Mediterranean diet, and to reduce food waste among Moroccan adolescents. To assess impact, two complementary questionnaires were used to collect information before and after the educational intervention. Each participant was compared on their own pre- and post-intervention data. This allowed for direct evaluation of changes in attitudes, knowledge and behaviour, while minimising the influence of individual differences among participants. The intervention was held in the participating students' classrooms and the questionnaires were also distributed in the participants' classrooms. This was done to maintain a familiar environment, limit context-related biases and ensure better representativeness of the data collected.

Research tools

Two structured questionnaires were used to collect data from the students. The first questionnaire, administered in May 2025 (T0), served to collect baseline information prior to the educational intervention. This questionnaire focused on assessing diet quality and adherence to the Mediterranean diet using the validated KIDMED questionnaire, a widely used tool for evaluating dietary patterns in children and adolescents. This questionnaire comprises 16 questions about the frequency of consumption of food groups characteristic of the Mediterranean diet, as well as about certain eating habits. Each question is scored positively or negatively according to its alignment with the principles of the Mediterranean diet, resulting in an overall score reflecting the level of adherence. In the study questionnaire, additional sections were included to capture students' knowledge, attitudes and beliefs regarding healthy eating, sustainability and food waste, providing a comprehensive baseline for later

comparison. Using this questionnaire allowed researchers to assess changes in participants' eating habits and determine whether the intervention had promoted the adoption of a healthier and more sustainable diet.

The second questionnaire (administrated the same time as the first one [T0]) aimed to assess behaviours related to food waste. It covered several dimensions, including the frequency of waste, portion control and practices for reusing leftover food. These elements were selected to measure the behavioural changes targeted by the intervention, specifically adolescents' ability to reduce food waste and make better use of leftovers at home. Detail was sought in some areas: Students reported the foods most frequently wasted, the number of days per week they discarded food and the approximate quantity of food thrown away daily. These data offered a detailed overview of household- and individual-level food waste behaviours, serving as a crucial baseline for evaluating the effectiveness of the intervention.

The same questionnaires were administered the second time in October 2025 (T1). This step, combined with direct observations by the Principal Investigator (PI) during the intervention, allowed for a thorough assessment of the programme's effectiveness; that is, the impact of the educational programme on the adolescents' knowledge, attitudes and practices. More specifically, variations in responses to the food waste questionnaire allowed the measurement of changes in waste reduction behaviours. This methodological approach thus ensured a consistent and direct evaluation of the study's objectives.

In summary, data collection was organised into three distinct phases: A pre-test phase (pilot testing of the instrument) conducted with a small group of students not included in the final sample to verify the clarity of the items, the comprehensibility of the questions, and the relevance of the responses. This step allowed for the identification of any ambiguities and the implementation of necessary adjustments to the questionnaire before its final administration. This was followed by the baseline test phase (T0, before the intervention) and the post-test phase (T1, after the intervention) using the same measurement instruments. Refelective notes were kept by the PI of observations made during the intervention delivery in the students' classrooms.

The questionnaires were administered to the same students during both phases of the study under strictly identical conditions. Each administration session

took place in the presence of the classroom teacher and the PI, thus ensuring standardised guidance and direct supervision of the process. Before each questionnaire administration, clear and consistent instructions were given to the students to explain the study's objective, the response procedures and the anonymity of the data. It was emphasised that there were no right or wrong answers and that responses should reflect their actual practices.

The average time to complete the questionnaire was approximately 30 minutes per session. This duration was deemed sufficient to allow for adequate understanding of the items while minimising fatigue or loss of attention among the participants. To ensure the reproducibility of the study, the same administration conditions were strictly adhered to during the post-test: same setting (classroom), same time of day when possible, same instructions and same method of questionnaire administration. This standardisation aimed to reduce measurement bias and ensure data comparability between the two assessment times.

The present manuscript focuses specifically on the impact of the educational intervention on food waste behaviours among high school adolescents.

Educational intervention

The intervention consisted of a series of complementary training activities conducted between September and October 2025. The intervention took place in the participants' schools, directly in the classrooms, to ensure a familiar environment. The programme, designed as a structured, multi-session intervention, aimed to improve adolescents' knowledge, attitudes and behaviours regarding food waste. The main components included:

1. Thematic training sessions designed to raise awareness of the impact of wasted meals on future generations. These sessions addressed the consequences of food waste on the environment, the economy and natural resources. Real-life examples and case studies were used to improve understanding and engagement.
2. Various active learning methods to encourage student participation such as:
   • Interactive activities and educational games in the classroom, including exercises in sorting wasted food, quizzes and role-playing scenarios simulating household food management and the reuse of leftovers;

• Multimedia resources, including short videos and social media content illustrating the issues of food waste and anti-waste initiatives worldwide;
• Group work and guided discussions, allowing students to reflect on their eating habits and identify behaviours that risk contributing to food waste.

3. A participatory approach directly involving the students in the development of the teaching materials. Participants created audio podcasts addressing the definition of food waste, its main causes, its consequences and global movements and campaigns against food waste. This approach aimed to reinforce learning through active participation and peer education.
4. "Zero Food Waste" challenge at home: Students were encouraged to reuse leftovers, particularly bread and dairy products, which were commonly wasted. Practical demonstrations of food preservation techniques were provided to extend freshness, and participants were motivated to implement these strategies at home. Examples of leftover-based recipes included in the intervention are:

- Bread-based recipes:
  - *Bread pudding*: Using stale bread combined with milk, eggs and fruit to create a sweet or savoury dish.
  - *Croutons (toasted bread cubes)*: Stale bread cubes baked with olive oil and herbs to accompany salads or soups.
  - Bread omelette: Stale bread sautéed, soaked in milk and eggs and combined with vegetables or cheese.
- Dairy-based recipes:
  - *Cheese and vegetable frittata*: Leftover cheese mixed with eggs and vegetables to make a nutritious dish.
  - *Yoghurt smoothies*: Using slightly overripe fruit with yoghurt to create a healthy drink.
  - *Baked milk custard*: Milk, eggs and flavorings (e.g., vanilla or cocoa) baked into a dessert.
- Combination recipes:
  - *Savoury bread gratin*: Stale bread, leftover cheese and milk, layered with vegetables or thinly sliced meats and baked until golden.
  - *Mini sandwiches or sliders*: Using leftover bread and cheese with spreads to create small snack portions, promoting portion control and reducing waste.

These practical activities allowed students to experience the benefits of food recycling, while learning concrete strategies to prevent food waste in their households.

The students demonstrated a high level of engagement throughout the intervention. Interactive activities, including videos and podcast creation, generated significant interest and active participation. Classroom discussions revealed a good understanding of the educational messages, as well as a marked interest in anti-waste campaigns and social media content.

Data analysis

Data analysis was conducted using a mixed-methods approach, combining quantitative and qualitative methods. Responses to closed-ended questions about food waste behaviours were coded and then entered into SPSS for statistical analysis. Descriptive statistics (frequencies and percentages) were calculated to assess the distribution of responses before and after the intervention. This quantitative analysis identified changes in adolescents' food waste behaviours.

In parallel, responses to open-ended questions about food waste were analysed thematically. Initially, all responses were read several times to familiarise the researchers with the data. Initial coding was then performed by identifying relevant units of meaning related to food waste practices, including portion size control (e.g., “I often leave leftovers on my plate”), reusing leftovers (e.g., “I turn stale bread into a meal”), meal planning (e.g., “We buy too much food”), and awareness of food waste (e.g., “I didn’t realise I wasted so much”).

These initial codes were then grouped into categories based on their similarities. Through an iterative process, these categories were refined and organised into main themes related to the study aims and research questions including awareness and understanding of food waste, food management and portion control practices, strategies for reducing food waste (such as leftover reuse and meal planning) and behavioural changes following the educational intervention. The resulting themes were then checked to ensure their consistency and alignment with the study objectives.
Finally, the qualitative results were used to complement the quantitative analyses from SPSS to provide a more comprehensive understanding of the intervention’s impact on food waste behaviours among adolescents.

Results

The surveyed sample comprised 200 school-aged adolescents, where 40% of the participants were boys and 60% were girls, reflecting a slightly higher female representation.

Analysis of data collected prior to the educational intervention, revealed important patterns in food waste behaviours, indicating that food waste was a frequent and significant issue among the adolescents in this population. Specifically, 60% of the participants reported discarding leftover food at least twice per week. Notably, this behaviour varied by residential context: urban adolescents exhibited a higher rate of food waste (70%) compared to their rural counterparts (30%), suggesting that lifestyle, availability of food and household practices may influence waste behaviours.

The types of foods most commonly wasted were bread (43.7%), vegetables (19.8%) and fruit (10%), which are staple components of the adolescents' diets. Bread was the food item most frequently discarded, highlighting its prominence in daily meals and the potential for significant reductions through targeted interventions.
When asked about the reasons for discarding food, adolescents primarily cited overly large portion sizes (27.8%) and lack of appetite (16%), indicating that both structural and behavioural factors contribute to waste. Portion size appears to be a modifiable factor that could be addressed through educational and household strategies, while lack of appetite may reflect individual eating habits or meal planning practices.

These findings underscore the necessity of intervention programmes that are tailored to both behavioural and environmental determinants of food waste. By understanding the specific foods most commonly wasted and the reasons behind these behaviours, educators and policymakers can design targeted strategies that are likely to yield measurable reductions in food waste among adolescents.

The results further revealed that although the majority of adolescents initially recognised the importance of the food waste problem, only 10% were taking concrete steps to reduce it. This finding underscores the gap between awareness and action, highlighting the necessity of structured educational interventions to promote behavioural change.

The results are presented below in more detail, according to two main outcome domains.

Outcome 1: Reduction in food waste quantity after the intervention

Following the educational intervention, a marked improvement in the food waste behaviour of the participants was observed, indicating the positive impact of the training programme. In particular, there was a substantial decrease in the rate of bread and dairy waste, as well as reductions in other food categories, as illustrated in figure 1. These results suggest that the intervention successfully translated knowledge and awareness into practical actions, demonstrating the value of combining educational content with hands-on activities.

Figure 1 *Amount of Food Wasted Before and After the Intervention (g/student/day)*

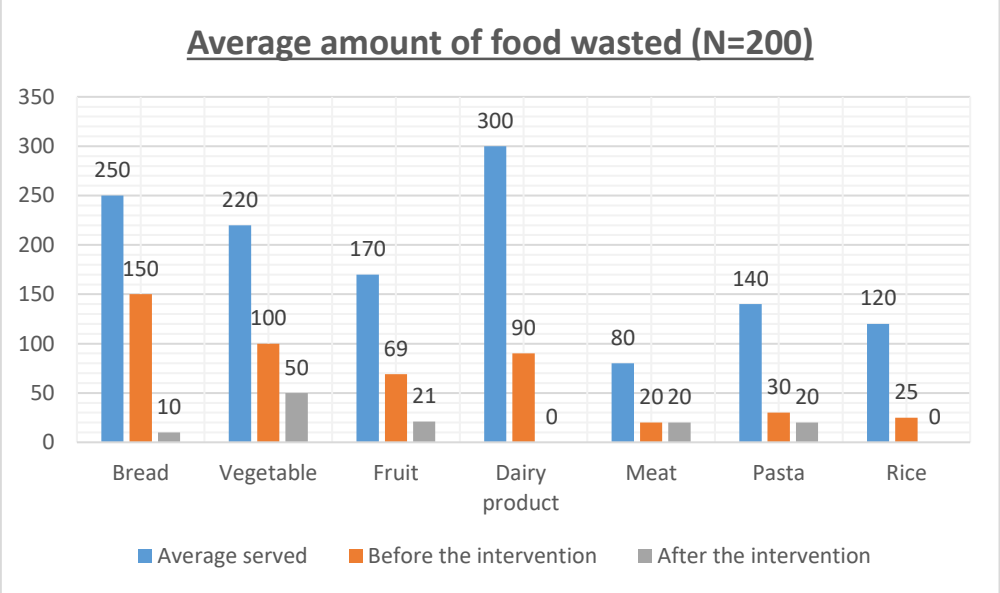


Figure 1 illustrates the changes in the average amount of food wasted among adolescents before and after participation in the educational sessions aimed at reducing food waste. The analysis considers multiple food categories, including bread, vegetables, fruit, dairy products, meat, pasta and rice, providing a comprehensive overview of waste patterns across the participants' typical diets.

Three distinct measurements are compared in the figure: the average amount of food served, the waste observed prior to the education sessions, and the

waste observed following the intervention. The figure allows for visual comparison across food categories, highlighting the variable impact of the intervention depending on the type of food.

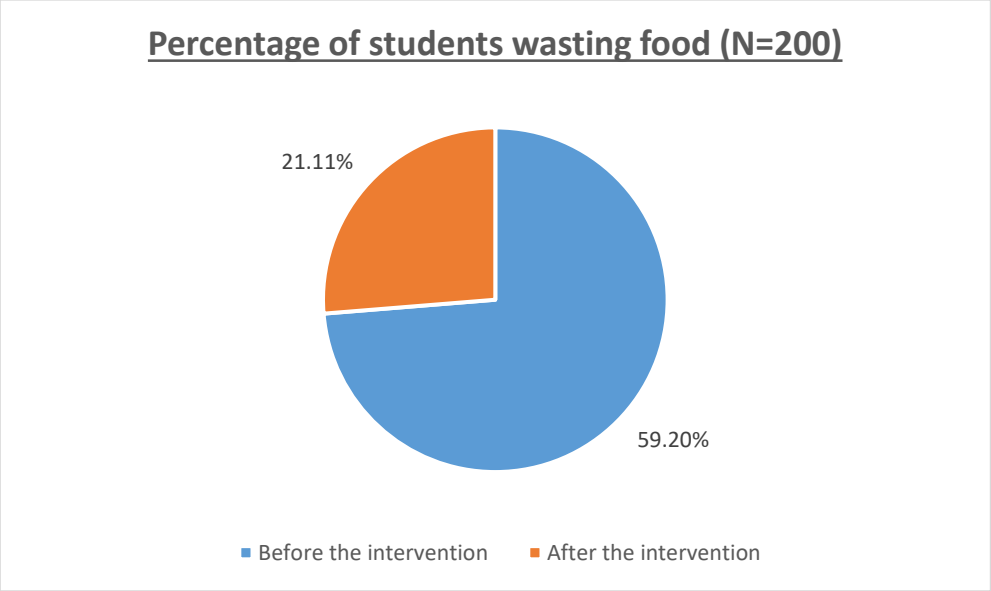
Overall, figure 1 provides a clear illustration of the effectiveness of the educational programme in promoting more sustainable food consumption behaviours among adolescents. These results demonstrate a marked decrease in food waste across all food categories following the educational training sessions, with particularly substantial reductions observed for bread and dairy products. The pronounced decrease in these two food categories can be attributed to the fact that the majority of the anti-waste recipes and hands-on activities presented during the training incorporated bread and dairy as primary ingredients. By directly engaging students in practical reuse and zero-waste cooking exercises, the intervention effectively reinforced the importance of these foods and demonstrated concrete strategies to reduce waste.

Quantitatively, the average bread waste decreased from 150 g per student per day before the training to only 10 g per student per day afterward, representing a reduction of approximately 93%. Similarly, dairy product waste decreased from 90 g to 0 g per student per day, indicating a complete elimination of waste for this category among the participants. These figures highlight the effectiveness of targeted interventions, particularly when the educational content is closely aligned with the foods most commonly wasted in daily practice.

Notably, while reductions were most significant for items directly targeted by the intervention, more moderate changes were also observed for vegetables, fruit, pasta, rice and meat, reflecting the relative emphasis of the training content. Specifically, vegetable waste decreased from 100 g to 50 g per student per day and fruit waste declined from 69 g to 21 g per student per day. These reductions, while smaller in magnitude than for bread and dairy, indicate again that the educational intervention had a positive influence on a broad range of food categories. In contrast, meat, pasta and rice demonstrated only minor decreases in waste, reflecting their limited incorporation in the anti-waste recipes and practical activities presented during the educational intervention. This pattern suggests that the effectiveness of the intervention is strongly linked to the foods targeted by the educational strategies and hands-on activities, reinforcing previous observations that interventions are most impactful when they focus on specific, frequently wasted foods.

By providing practical examples of how to reuse leftovers and implement zero-waste strategies at home, the training encouraged adolescents to actively apply the lessons learned. Additionally, these hands-on activities likely reinforced habit formation, increasing the likelihood that these behaviours will be maintained over time. Furthermore, the intervention appears to have enhanced participants' understanding of how individual actions can contribute to environmental and social sustainability, reinforcing the connection between personal responsibility and broader ecological impacts. This supports the notion that educational interventions can bridge the gap between knowledge and practice, fostering sustainable food behaviours even in age groups traditionally resistant to behavioural change.

Figure 2 *Changes in Food Waste among Students Before and After the Intervention*



The data suggest that practical engagement, combined with theoretical knowledge, is a highly effective method for promoting behavioural change. By focusing on foods that are both highly consumed and highly wasted, the intervention was able to achieve substantial reductions in a short period, demonstrating the potential of school-based programmes to influence sustainable eating behaviours. The success observed with bread and dairy products also underscores the value of hands-on, participatory approaches in which students actively implement strategies in real-life contexts, rather than simply receiving information passively.

Following this intervention, a very positive change in students' overall behaviour regarding food waste was also observed. This is illustrated in figure 2. The figure provides a visual summary of the before-and-after differences across all food categories, reinforcing the conclusion that hands-on educational strategies can significantly alter eating habits and foster sustainable consumption practices among young people.

Figure 2 illustrates the changes in food waste behaviours among students before and after the educational intervention. The pie chart clearly shows a substantial reduction in the proportion of students wasting food: prior to the training, 59.20% of students reported discarding food, whereas after the intervention, this percentage dropped to 21.11%. This represents a relative decrease of approximately 64%, highlighting the effectiveness of the awareness campaign and the practical training activities in promoting sustainable food behaviours among adolescents.

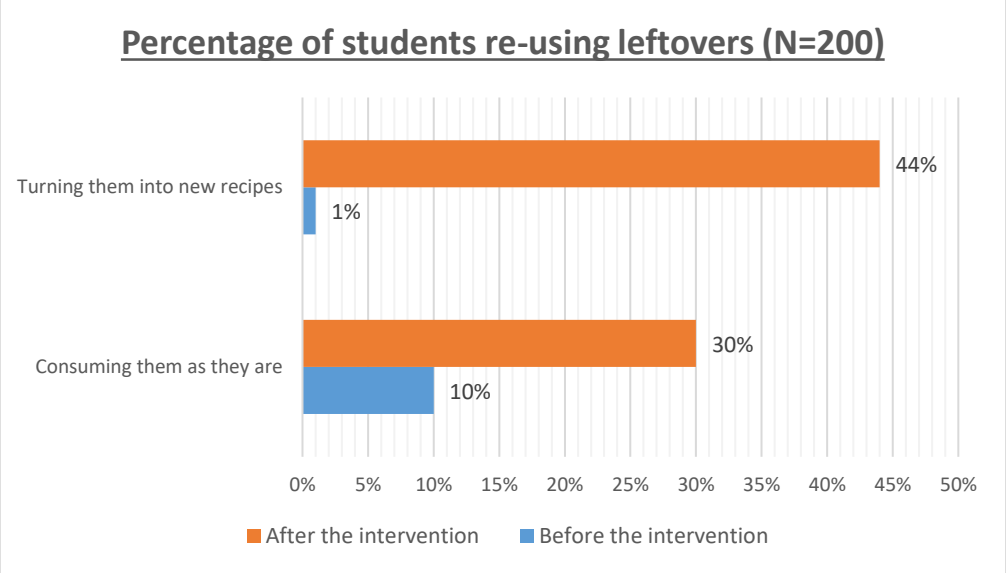
These results provide strong evidence of the impact of the educational intervention on students' eating habits and daily practices. The training appears to have fostered knowledge awareness of the environmental consequences of food waste, encouraging students to reconsider their consumption patterns. The significant reduction in reported food waste suggests that the intervention effectively influenced both perceptions and attitudes, enabling participants to adopt more responsible behaviours in their everyday lives.

Outcome 2: Changes in food consumption behaviour related to food waste

The intervention equipped students with practical strategies to reduce waste, such as proper portioning, reuse of leftovers and preservation techniques, which likely contributed to the observed behavioural changes. The training also encouraged using leftovers which would otherwise have been discarded, thus extending the educational impact beyond mere awareness.

The observed changes in figure 2 are further supported by data presented in Figure 3, which illustrates the specific strategies adopted by students to reduce food waste at home. Together, these figures demonstrate the effectiveness of combining knowledge-based instruction with practical, participatory learning in fostering sustainable dietary habits among adolescents.

Figure 3. *Percentage of Students Re-using Leftovers*



The study data indicate that prior to the educational intervention, only 1% of students reported consuming or reusing food scraps, reflecting a very limited practice of sustainable food management among adolescents. Following the intervention, this figure increased dramatically to 44%, demonstrating a remarkable behavioural shift and highlighting the effectiveness of the practical training provided.

The training in this intervention was based on skills transfer and experiential learning, enabling students not only to reduce food waste, but also to actively repurpose leftovers into new and appealing dishes. By encouraging adolescents to transform food scraps into creative recipes, often by reinventing traditional dishes, the hands-on activities directly contributed to fostering sustainable consumption practices.

This approach fostered both cognitive and practical skills, as students learned to plan meals, manage portions and creatively reuse ingredients that would otherwise have been discarded. The success of this component demonstrates that educational interventions emphasising practical application, creativity and culinary skills can significantly enhance sustainable behaviours, providing adolescents with the tools to integrate responsible eating habits into their daily lives.

Moreover, these findings suggest that behavioural change is most effective when adolescents are empowered with actionable strategies, rather than solely

receiving information. By combining awareness-raising with participatory and skill-based activities, the intervention not only increased knowledge but also promoted long-term behavioural adoption, ensuring that the lessons learned extend beyond the classroom environment and into students' homes.

Discussion

Although the Mediterranean diet offers a model of sustainable eating, its adoption remains limited among young people. It is with this in mind that the survey conducted in this study among school-aged adolescents initially aimed to analyse their dietary habits and assess the extent of food waste. The second phase sought to evaluate the impact of an educational intervention specifically designed to change the behaviour of school-aged adolescents to reduce food waste.

This study is particularly interesting because it reports the results of an intervention targeting an age group that represents a critical turning point in young people's lives, during which habits are formed that can affect their future health as adults. Adolescence is a stage characterised by increased autonomy in food choices, making it an ideal period to promote sustainable dietary practices and reduce environmentally detrimental behaviours, such as food waste.

Indeed, the data presented here demonstrates a significant reduction in food waste following the educational training included in this intervention, particularly for bread and dairy products, two food categories widely incorporated in the zero-waste recipes offered to adolescents during the sessions. This result is consistent with observations reported in other studies, where educational and behavioural interventions have been shown to effectively reduce food waste. For instance, a systematic review found that 67% of the interventions studied resulted in a significant reduction in food waste (Liechti et al., 2024). Moreover, multi-component interventions combining awareness-raising, nudges and knowledge reinforcement produced the most substantial reductions, reaching up to 84.3%.

These results align with the present study, in which the implemented training integrated both practical information and hands-on learning activities, such as zero-waste recipes. The combination of theoretical knowledge with actionable, practical strategies likely contributed to the substantial reduction in waste observed for the targeted foods. The inclusion of participatory activities also

appears to enhance engagement and motivation among adolescents, supporting lasting behavioural change.

Other important environmental and structural factors identified as contributing to food waste reduction include portion sizes and food presentation. In this regard, previous studies have shown that relatively simple modifications to portion sizes, along with information campaigns, can reduce food waste by up to 57% (Reynolds and Quested, 2019). These results reinforce the notion that combining practical information with behavioural strategies can effectively promote the adoption of sustainable practices among young people.

In the present study, the more moderate reduction observed for vegetables, fruits, meat, pasta and rice may be explained by the lesser focus on these foods in the educational training. This observation is consistent with findings reported by Liechti et al. (2024), highlighting a generally greater impact for the directly targeted foods by the content or practical tools of the intervention. This suggests that, to maximise the effectiveness of food waste reduction programmes, interventions should be contextualised, personalised and targeted, while incorporating both educational and practical strategies adapted to participants' eating habits.

Furthermore, these results indicate that repeated exposure to targeted messages, practical demonstrations and interactive activities can reinforce learning and behavioural change. Encouraging students to engage in activities at home, such as the zero-waste challenge, may strengthen the transfer of knowledge from the classroom to everyday practices, thereby increasing the sustainability of these interventions.

In conclusion, the data from this study confirms that training programmes which combine practical information, recipes and behavioural awareness can effectively reduce food waste, particularly for the most commonly consumed foods, or those most frequently used in educational activities. These findings underscore the importance of integrating hands-on, culturally relevant approaches into educational programmes aimed at adolescents to foster sustainable dietary behaviours.

Conclusion

This study demonstrates that education is an effective tool for reducing food waste among adolescents. The educational intervention implemented in this study led to observable changes in behaviours often considered deeply ingrained, confirming that adolescence represents a critical period for the adoption of responsible consumption practices. The significant decrease in food waste observed among participants suggests that much of the initial waste was linked to a lack of awareness regarding environmental, economic and social consequences.

The study also indicates that educational programmes combining theoretical knowledge with practical, recipe-based activities can successfully reduce food waste among adolescents. The intervention was particularly effective for foods directly emphasised in the educational content, highlighting the value of contextualised, participatory approaches that engage students in active problem-solving and skill development.

The study further highlights the potential value of combining educational initiatives with structural measures, such as adjusting portion sizes, improving food storage and facilitating the reuse of leftovers, to strengthen and sustain the impact of interventions. By targeting both knowledge and practical behaviours, schools can play a pivotal role in promoting sustainable dietary habits and contributing to the broader goals of environmental conservation and food system sustainability.

Finally, despite the interesting results of this study, it is important to highlight certain limitations that open up promising avenues for future research. Among these limitations, the sample size could be increased to improve its representativeness, strengthen the statistical power of the results, and allow for their extrapolation to other school-aged adolescents in different regions. Another limitation lies in the self-reported nature of the data and the short duration of the intervention follow-up; subsequent, longer-term studies could address these limitations. Furthermore, the potential influence of external factors on food waste behaviours and potential reduction, such as family background or socioeconomic status, underscores the importance of adopting a broader, multidimensional approach to exploring and improving student food waste reduction behaviours in future research.

References

Agya, B. A. (2025). Technological solutions and consumer behaviour in mitigating food waste: A global assessment across income levels. *Sustainable Production and Consumption*, *55*, 242-256. https://doi.org/10.1016/j.spc.2025.02.020

Alexandratos, N. and Bruinsma, J. (2012). *World agriculture towards 2030/2050: The 2012 revision.* ESA Working paper No. 12-03. Rome, FAO. https://acrobat.adobe.com/id/urn:aaid:sc:EU:1f12eef3-bdf4-481b-8f7a-4d73bf00c0c0

Carvalho, N. A., & Martins, M. C. (2024). Education to promote healthy and sustainable eating habits: A bibliometric analysis. *Sustainability*, 16(22), 9750. https://doi.org/10.3390/su16229750

Di Nucci, A., Silano, M., & Cardamone, E. (2025). Adherence to Mediterranean Diet and health outcomes in adolescents: An umbrella review. *Nutrition reviews*, *83*(3), e1329–e1342. https://doi.org/10.1093/nutrit/nuae085

FAO. (2017). The Future of Food and Agriculture—Trends and Challenges. Food and Agriculture Organization of the United Nations, Rome, 296, 1-180. https://acrobat.adobe.com/id/urn:aaid:sc:EU:3b9f641e-d31b-463b-bda7-30ecc278904a

FAO (2019). *The State of Food and Agriculture 2019*.Moving forward on food loss and waste reduction. Rome. Licence: CC BY-NC-SA 3.0 IGO. https://acrobat.adobe.com/id/urn:aaid:sc:EU:a28c2642-044c-4c79-b97a-9a46bc0b176c

Global Panel. (2017). *Urban diets and nutrition: Trends, challenges and opportunities for policy action. Policy Brief No. 9.* London, UK: Global Panel on Agriculture and Food Systems for Nutrition. https://www.glopan.org/sites/default/files/Downloads/GlobalPanelUrbanizationPolicyBrief.pdf

Hachem, F., Capone, R., Yannakoulia, M., Dernini, S., Hwalla, N., & Kalaitzidis, C. (2016). The Mediterranean diet: A sustainable consumption pattern. In *Mediterra* (pp. 243–261). FAO/CIHEAM/ Presses de Sciences Po (PFNSP). https://www.ciheam.org/uploads/attachments/449/10_Mediterra2016_EN.pdf

HLPE. (2014). *Food losses and waste in the context of sustainable food systems. A report by the High-Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.* Rome: HLPE. http://www.fao.org/3/a-i3901e.pdf

Iaccarino Idelson, P., Scalfi, L., & Valerio, G. (2017). Adherence to the Mediterranean diet in children and adolescents: A systematic review. *Nutrition, Metabolism & Cardiovascular Diseases,* 27(4), 283–299. https://doi.org/10.1016/j.numecd.2017.01.002

Ishangulyyev, R., Kim, S., & Lee, S. H. (2019). Understanding food loss and waste. Why are we losing and wasting food? *Foods*, *8*(8), 297. https://doi.org/10.3390/foods8080297

Kummu, M., de Moel, H., Porkka, M., Siebert, S., Varis, O., & Ward, P. J. (2012). Lost food, wasted resources: global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use. *The Science of the total environment*, *438*, 477–489. https://doi.org/10.1016/j.scitotenv.2012.08.092

Liechti, C., Mack, G., & Ammann, J. (2024). A systematic literature review of impactful food waste interventions at the consumer level. *Sustainable Production and Consumption, 52*, 552–565. https://doi.org/10.1016/j.spc.2024.11.023

Nucci, D., Stacchini, L., Villa, M., Passeri, C., Romano, N., Ferranti, R., Morsella, A., Veronese, N., Maggi, S., & Gianfredi, V. (2025). The role of Mediterranean diet in reducing household food waste: The UniFoodWaste study among Italian students. *International Journal of Food Sciences and Nutrition*, 76(4), 443–455. https://doi.org/10.1080/09637486.2025.2495719

Mondéjar-Jiménez, J. A., Ferrari, G., Secondi, L., & Principato, L. (2016). From the table to waste: An exploratory study on behaviour towards food waste of Spanish and Italian youths. *Journal of cleaner production*, *138*, 8-18. https://doi.org/10.1016/j.jclepro. 2016.06.018

Reynolds, C., Goucher, L., Quested, T., Bromley, S., Gillick, S., Wells, V.K., Evans, D., Koh, L., Kanyama, A.C., Katzeff, C. and Svenfelt, Å., & Jackson, P. (2019). Consumption-stage food waste reduction interventions : What works and how to design better interventions. *Food policy*, *83*, 7-27. https://doi.org/10.1016/j.foodpol.2019.01.009

Rockström, J., Thilsted, S. H., Willett, W. C., Gordon, L. J., Herrero, M., Hicks, C. C., Mason-D'Croz, D., Rao, N., Springmann, M., Wright, E. C., Agustina, R., Bajaj, S., Bunge, A. C., Carducci, B., Conti, C., Covic, N., Fanzo, J., Forouhi, N. G., Gibson, M. F., Gu, X., … & DeClerck, F. (2025). The EAT-Lancet Commission on healthy, sustainable, and just food systems. *Lancet,* 406(10512), 1625–1700. https://doi.org/10.1016/S0140-6736(25)01201-2

Souza, E. R., BinMowyna, M. N., Alfheeaid, H. A., Raposo, A., da Fonseca, P. G., & Guimarães, N. S. (2025). Nutritional intervention programs for sustainability: A scoping review on full food utilization and the clean leftovers reuse. *Nutrients, 17*(11), 1829. https://doi.org/10.3390/nu17111829

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006). *Livestock's long shadow: Environmental issues and options*. Food and Agriculture Organization of the United Nations (FAO).

United Nations Environment Programme. (2024). *Food Waste Index Report 2024. Think eat save. Tracking progress to halve global food waste.* United Nations Environment Programme. https://acrobat.adobe.com/id/urn:aaid:sc:EU:5df7ba70-e344-4973-9428-e3b82241b607

van der Werf, P., Seabrook, J. A., & Gilliland, J. A. (2019). "Reduce food waste, save money": Testing a novel intervention to reduce household food waste. https://doi.org/10.1177/0013916519875180

Varjani, S., Vyas, S., Su, J., Siddiqui, M. A., Qin, Z. H., Miao, Y., Liu, Z., Ethiraj, S., Mou, J.H., & Lin, C.S.K. (2024). Nexus of food waste and climate change

framework: Unravelling the links between impacts, projections, and emissions. *Environ. Pollut.,* 344 (2024), Article 123387. https://doi.org/10.1016/j.envpol.2024.123387

West, P. C., Gerber, J. S., Engstrom, P. M., Mueller, N. D., Brauman, K. A., Carlson, K. M., Cassidy, E. S., Johnston, M., MacDonald, G. K., Ray, D. K., & Siebert, S. (2014). Leverage points for improving global food security and the environment. Science, 345(6194), 325–328. https://doi.org/10.1126/science.124606

Wood, S. L. R., Alam, M., & Dupras, J. (2019). Multiple pathways to more sustainable diets: Shifts in diet composition, caloric intake and food waste. *Frontiers in Sustainable Food Systems,* 3(89). https://doi.org/10.3389/fsufs.2019.00089