Systematic literature review protocol

Heike B Rolker 1,2
Dr Laura Cardenas 2
Dr Taro Takahashi 1,2
Megan Deeney 3
Prof Mark Eisler 1

1 Bristol Veterinary School, University of Bristol, Langford, Bristol, BS40 5DU, United Kingdom
2 Rothamsted Research, North Wyke, Okehampton, Devon, EX20 2SB, United Kingdom
3 London School of Hygiene and Tropical Medicine, Keppel Street, London, WC1E 7HT, United Kingdom
INTERVENTIONS TO REDUCE PERISHABLE FOOD WASTE IN LOW- AND MIDDLE-INCOME COUNTRIES — A SYSTEMATIC LITERATURE REVIEW

1 BACKGROUND

In the last century, the quantities of food loss and waste have been rising globally, to the extent that the relative increase in waste has outpaced population growth (1). Of all food wasted, the share of fruit and vegetable waste increased the most, from 30% in the 1960s to 42% in 2011. Fruits, vegetables, animal and marine products, are perishable foods with short shelf-lives, often requiring refrigeration to slow down microbial growth and decay. Perishable foods are particularly susceptible to bruising and breakage, which favours rot and fast deterioration even further. In low-and-middle-income countries (LMICs), preventing perishable foods from being wasted is particularly challenging due to the lack of facilities and infrastructure for storage, processing and transport as well as limited knowledge of appropriate handling practices (2–4). The increase in fruit and vegetable waste has, for example, been predominantly driven by rapidly developing Asian nations like India and China (1). In many LMICs diets are shifting towards greater diversity, leading to a higher demand for perishable foods that are essential for a healthy diet (5). Waste of perishable foods is expected to continue to increase globally and more specifically in LMICs (6).

In recent efforts to standardise measurements and reporting across various study aims, the World Resources Institute defines food waste as “both food and associated inedible parts” that are “removed from the food supply chain” (7). Importantly, this definition acknowledges and is inclusive of differences across contexts and cultures to what parts of the food are considered edible, crucial for global comparisons. The removal from the supply chain can have many reasons: improper postharvest handling leading to breakage; inadequate storage conditions that speed up decay or favour insect infestation; processing to remove parts of the food such as peels or bones; or households’ over-purchasing behaviour where excess food may be left to rot and is discarded, to name a few (2–4). The waste hierarchy conceptualises and ranks waste management options from prevention, reuse, recycling, and recovery to the least preferable disposal option often in a landfill site. The waste hierarchy has been proposed as a useful framework for managing food waste while attaining sustainable benefits to societies, the environment and economics (7).

Preventing and reducing (i.e. reuse, recycle and recovery) food waste is expected to have wide-ranging benefits for livelihoods, biodiversity and ecosystems (8). In LMICs food insecurity is often a widespread concern, preventing food waste increases food availability and is likely to improve food security, nutrition and health (9,10). Reducing the volume or mass of waste through adequate waste management contributes to establishing a circular economy and improves resource efficiency (11,12).
At the household level this may be reflected in household savings, for example, through household energy generation (13). From an environmental perspective, reducing waste could conserve natural resources such as land or water (14,15) and excess production to disposal related emissions could be prevented (15,16).

Because of the broader expected impacts, the Food and Agriculture Organisation (FAO) calls for intervention to reduce food waste to be designed to also target broader benefits that contribute to sustainability, health and development goals (17). However, there is no systematic assessment on the progress on designing interventions that achieve these goals (18), nor has there been much innovation in providing robust methods to link the efforts to broader outcomes, like nutrition for example (19).

This study systematically reviews the published evidence on interventions intended to prevent and reduce food waste of perishables in LMICs. We use the definition provided by the World Resources Institute encompassing food and its inedible parts in the value chain after harvest to capture the breadth of the included studies’ aims. A systematic study of the literature will shed light on the effectiveness and distribution of interventions across the food value chains in LMICs and the various destinations for the waste. Further, it will improve our understanding of common barriers and facilitators to implementation. A secondary aim of this review is to identify the degree to which the interventions are designed in consideration of context-specific problems, as suggested by the FAO (17) and others (6,18,20,21). Many of the impacts of waste reduction on health and development have been hypothesised, particularly in international and reports from non-government organisations (17,20,21), but no systematic assessment of the effects of waste reduction interventions with regards to health and development outcomes has been made so far.

1.1 AIM
To systematically review interventions aimed at preventing and reducing food waste along the value chains of perishable foods in low-and-middle-income countries (LMICs)

1.2 SPECIFIC OBJECTIVES
1. To evaluate the effectiveness of perishable food waste prevention and reduction interventions in LMICs
2. To identify intervention-specific and context-specific enablers and barriers to implementation described in the literature
3. To identify co-benefits and pathways of waste interventions to sustainable development goals and health more specifically.

2 METHODS OF REVIEW

2.1 LITERATURE SEARCH
This systematic review follows Cochrane guidance on the process of conducting a systematic review and the PRISMA reporting statement. The first two screening steps (title and abstract, full-text) will be single screened with 10% double screening for agreement. One person will conduct the data extraction.
SEARCH STRATEGY
Conflicting and inconsistent definitions of food waste exist (12,22,23); for this review, we consider perishable foods, or any associated inedible parts removed from the supply chain as food waste. This follows the definition of the World Resources Institute (7) and others (24,25). As such, food waste can occur at every stage of the food supply chain: agricultural production (e.g. discarded animal products, unharvested crops), storage and transport (e.g. spillage, infestation, bruising), processing (e.g. animal by-products, fruit peel) and at the consumer level (e.g. spoiled food, household food waste) (24). Further, interventions are grouped in two main categories according to the waste hierarchy: “waste prevention” and “waste reduction” (i.e. reuse, recycling and recovery of waste) (12). As waste prevention we consider interventions aimed at counteracting, curtailing or decreasing the likelihood of food diminishing in quantity or quality; or entering a state of general inedibility due to food safety concerns, i.e. preventing food from becoming a waste material. Waste reduction interventions are aimed at minimising the quantities, mass or volume of food waste material in place. For example, by establishing organised waste management systems to lessen unstructured dumping of waste or disposal in landfill; or by diverting or recycling food waste material for alternative uses.

The search terms are designed with the help of a Bristol University subject librarian to capture studies discussing waste of perishable foods and the interventions to prevent and reduce waste. We use terms related to perishable food products, waste, and intervention terms related to waste prevention and management, we combine them with Boolean and proximity operators. We adapt the final search syntax iteratively to each database. The intervention terms relate to waste management and the food waste hierarchy (26). Further, we apply an adapted version of a Cochrane devised filter for low- and middle-income countries (27). An example search string can be found in the Appendix, and the search concepts are as follows:

Search concepts:

1) Perishable products (e.g. fruit, vegetables, meat, animal and marine products)
2) Wastes and losses (e.g. food losses, waste, wastage, by-product)
3) Interventions (e.g. prevent, reuse, recycle, repurpose, recover, circular economy)
4) LMICs

In 2011 the FAO published the first global assessment and quantification of food losses and waste in a landmark report, thus drawing significant attention to the issue. Since then, scientific publications related to food waste have increased as well. We, therefore, limit the search to publications from the year 2011 onwards.

The following scientific and grey literature sources will be searched:

Table 1 Databases for literature search

<table>
<thead>
<tr>
<th>Scientific databases</th>
<th>CAB Abstracts, EconLit, Web of Science, Scopus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grey literature sources</td>
<td>AGRIS (FAO), IFPRI e-library, PubAg, GAIN, Worldbank repository, WRAP</td>
</tr>
</tbody>
</table>
2.2 Screening and data extraction

All searches will be conducted between January and March 2021, results will be imported to Endnote and duplicates will be removed. Screening for eligibility takes place at two stages: title and abstract, followed by full-text screening. Screening at title and abstract will be conducted using the Rayyan online tool (28), full-text retrieval and full-text screening are done in Endnote. A randomly selected proportion (10%) will be double-screened at both stages by an independent researcher, and conflicts will be resolved through discussion. Where relevant, literature reviews will be hand searched for additional references.

Criteria for including studies in this review

Eligibility for inclusion is based on the criteria presented in Table 2. We used the PICO framework to develop the criteria. In short: interventions aimed at populations in LMICs and targeted at perishable food products and their inedible parts, e.g. banana or banana peel are of interest; interventions fall in two categories a) ‘waste prevention’: targeted strategies to prevent waste from occurring or b) ‘waste reduction’: strategies to reduce the amount of existing waste as conceptualised in the waste hierarchy (e.g. reuse, recycle, recovery of waste); any comparator or control treatment, including statistical matching, will be included given the intervention takes place in a real-life context; lastly, the primary outcomes that will be considered are quantifications of waste prevention (e.g. quality, quantity or nutritional) or reduction (e.g. decrease in volume, mass or uncontrolled disposal) achieved through the intervention. All secondary outcomes and destination sectors will be considered.

Table 2 Inclusion and exclusion criteria

<table>
<thead>
<tr>
<th>Eligibility Criteria</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
</tr>
</thead>
</table>
| Condition of interest| • Perishable food products, i.e. marine foods, animal products, fruits, vegetables, roots and tubers  
• Any component, food product, agricultural product, inedible part, by- or co-product that originated from a perishable food in the course of its progression through the value chain, e.g. fruit and vegetable peel, bones or skin | • Waste not related to perishable foods, e.g. grains, nuts, legumes  
• Other types of waste such as packaging material (e.g. plastic, paper, carton, fertiliser)  
• Waste not related to food (building material or other)  
• Non-specified solid municipal waste or mixed waste  
• Non-specified agricultural waste |
| Interventions and exposure | • Interventions explicitly aimed at avoiding or preventing food losses and waste  
• Interventions explicitly aimed at reducing waste through reusing, recycling or repurposing within the food system or other industries | • Interventions aimed at preventing pre-harvest losses as they relate to closing yield gaps or managing animal disease  
• Interventions aimed at prolonging shelf-life or delaying decay unless it is
The intervention could be: a program, project, policy, technology or management strategy aimed at preventing, reducing, reusing or recycling waste generated anywhere in the food supply chain specified by how much waste generation was averted.

**Comparisons or control groups**
- Provides a clear comparison between different situations: before and after, exposed and non-exposed; different treatment groups
- Descriptive comparisons between adopters and non-adopters

**Primary outcomes**
- Any absolute or relative measure of waste prevented in terms of quantity (e.g. weight, unit) or quality (e.g. nutrient content, spoilage or appearance)
- Any absolute or relative measure of waste reduced through reuse, recycling or recovery (e.g. change in volume and mass or units used)
- Any absolute or relative measure of waste disposed of in a landfill site or elsewhere
- Waste management interventions that do not quantify the waste reduction
- Losses and waste only quantified in economic terms as financial losses

**Secondary outcomes**
- All additional outcomes related to context-specific problems or co-benefits in the population or setting, e.g. changes in household income, nutrition status, environmental outcomes, energy generation
- Studies describing secondary outcomes described in the absence of primary outcomes

**Setting**
- Interventions applied at any step in the food supply chain in LMICs: production, storage, processing, transport, retail and consumption
- Interventions implemented in high-income-countries
- Laboratory settings or field experiments without the participation of any food supply chain stakeholders

**Study designs**
- Any valid study design is permissible if it meets the above criteria and presents original data, e.g. randomised-controlled trials, non-experimental designs with statistical matching or modelling
- Literature reviews
- Does not contain original data
- Observational and descriptive studies

**Additional exclusion criteria**
- Languages that are not German, Dutch, Spanish, French or English
- Publications since 2011 will be assessed
2.3 DATA EXTRACTION

Data will be extracted using an Excel form that covers the following study and interventions specific information.

General:
- Bibliographic details (author, title, year, journal, publication type, DOI, URL)

Setting:
- Country, the region within a country, intervention setting (e.g. on-farm community, household)

Intervention details:
- Commodity (i.e. fruit, vegetable, animal product)
- Food value chain stage ("source of waste")
- Waste management category
  - prevention
  - reduction: reuse, recycle, recovery
  - disposal
- Type of intervention (e.g. technology, policy, material)
- Cost of intervention
- Resources required (e.g. energy, infrastructure, transport, etc.)

Population:
- Type of food value chain actor
- Gender, sample size

Outcome:
- Type of waste (qualitative, quantitative, by-product, other), effect size, unit
- Assessment method used
- Destination sector and output (where relevant)
- Secondary outcome domain (e.g. health, energy, economic)

Study details:
- Study design
- Funding source

Barriers or enablers to implementation described:
- Yes/no

2.4 ANALYSIS AND SYNTHESIS

In our data analysis and synthesis, we will quantify the frequency and distribution of interventions across the food value chain, food commodities and countries. We classify the interventions into two categories: waste prevention and waste reduction, which we will further break down into intervention types based on common features. We expect heterogeneity in intervention-outcome combinations, so where data permit, we will report the mean effect size of specific interventions with box plots and confidence intervals. All descriptive and quantitative analyses will be conducted using R (29). We will conduct a thematic analysis of secondary outcomes as they relate to broader impacts and the sustainable development goals and corresponding theories of change.

Moreover, we will describe the context-specific factors as they relate to the implementation of the interventions, such as barriers and enablers of implementation.
2.5 **Quality Appraisal and Risk of Bias**

We will assess the study quality and risk of bias using an adapted checklist for randomised trials from the Critical Appraisal Skills Programme (CASP) (30), each study will receive a score out of eleven. The following questions will be used to assess the quality of studies that meet the inclusion criteria:

- Is there a clear description of the food commodity of interest?
- Does the intervention directly target and involve local value chain actors in the intervention?
- Were human participants randomly assigned to the interventions or were adequate methods used to minimize bias (i.e. propensity score matching, difference-in-difference)?
- Is the study area clearly justified?
- Are the intervention design and implementation methods clearly described?
- Are the outcome assessments methods and measures clearly justified?
- Was the intervention compared to an appropriate and comparable intervention or control situation (i.e. different treatments, control group, pre-post testing)?
- Were baseline characteristics of the commodity clearly described and are they similar across intervention groups?
- Were the effects of the intervention reported comprehensively?
- Are sufficient data presented to support the findings, including the precision of the estimate?
- Does the study consider unintended consequences, inputs required, upkeep and sustainability?

**Acknowledgements**

We are grateful to Emma Place, subject librarian at Bristol Veterinary School for the support in developing the search syntax and to Nasser Fardousi for providing feedback on the early draft.
3 REFERENCES


27. Cochrane. EPOC LMIC filters 2020 (v.4) [Internet]. undefined. 2020. Available from: https://epoc.cochrane.org/lmic-filters


## Appendix

### Search syntax and results for CAB Abstracts

<table>
<thead>
<tr>
<th>Row</th>
<th>Search string</th>
<th>Results</th>
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<tr>
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<td>(((animal* or livestock* or poultry* or lamb* or goat* or mutton* or sheep or chicken or duck* or cattle or beef or cow* or pork or swine or pig*) adj3 (&quot;food waste*&quot; or &quot;food loss*&quot; or loss* or waste* or wastage or surplus or discard* or break* or bruise* or damage* or &quot;by-product*&quot; or byproduct*)).mp.</td>
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