Ciência & Saúde Coletiva
cienciaesaudecoletiva.com.br
ISSN 1413-8123. v.29, n.10
DOI: 10.1590/1413-812320242910.04532023

Food loss and food waste research in Latin America: scoping review

Perda e desperdício de alimentos na América Latina: revisão de escopo

Bruna Vieira de Lima Costa (https://orcid.org/0000-0003-3552-7729) [1]
Nayhanne Gomes Cordeiro (https://orcid.org/0000-0002-1110-8944) [1]
Victória Bortolosso Bocardi (https://orcid.org/0000-0002-5244-2703) [1]
Gislene Regina Fernandes (https://orcid.org/0000-0003-0029-0936) [2]
Simone Cardoso Lisboa Pereira (https://orcid.org/0000-0001-9261-2597) [1]
Rafael Moreira Claro (https://orcid.org/0000-0001-9690-575X) [1]
Camila Kümmel Duarte (https://orcid.org/0000-0003-1930-3282) [1]

Abstract *The article aims to identify stage of the food supply chain (FSC) has the greatest food loss and waste (FLW), the factors that influence and economic, social and environmental impacts in Latin America countries. We carried out a scoping review of observational studies, case reports and interventional studies in January 2023. Searches were performed in scientific databases and hand-searching of reference lists. Data on the included studies were summarized with narrative synthesis. In total 16 articles met the inclusion criteria. The greatest FLW occur in the early and middle stages of the FSC, mainly during storage. The main causes were connected to financial, managerial and operational limitations related in harvesting techniques, storage and cooling facilities, infrastructure and marketing systems. Food waste (FW) is also a result of lack of appropriate storage facilities and efficient transport systems, market fluctuations and systems. Only one study presented results on the environmental impact of FW. There is a higher occurrence of food loss, characterized by decrease in the quantity and quality of food in the first three stages of FSC.*

Key words *Food Loss, Food Waste, Food supply chain, Food production, Latin America*

Resumo *O objetivo do artigo é identificar etapa da cadeia de abastecimento de alimentos (CAA) com maior perda e desperdício de alimentos (PDA), os fatores que influenciam e os impactos econômicos, sociais e ambientais nos países da América Latina. Realizamos revisão de escopo de estudos observacionais, relatos de caso e estudos intervencionais em janeiro de 2023. As buscas foram realizadas em bases de dados científicas e busca manual de listas de referências. Os dados dos estudos incluídos foram resumidos com síntese narrativa. No total, 16 artigos atenderam aos critérios de elegibilidade. As maiores PDA ocorrem nas fases inicial e intermediária do CAA, principalmente durante o armazenamento. Principais causas das perdas eram financeiras, gerenciais e operacionais relacionadas a técnicas de colheita, instalações de armazenamento e resfriamento, infraestrutura e sistemas de comercialização. Desperdício é resultado da falta de instalações de armazenamento adequadas e sistemas de transporte eficientes, flutuações de mercado e de sistemas. Um estudo apresentou resultados sobre o impacto ambiental das perdas. Há maior ocorrência de perdas alimentares, caracterizadas pela diminuição da quantidade e qualidade dos alimentos nas etapas iniciais da CAA.*

Palavras-chave *Perda de alimentos, Desperdício de alimentos, Cadeia de Abastecimento de Alimentos, Produção de Alimentos, América Latina*

[1] Grupo de Pesquisa em Estudos, Pesquisas e Práticas no Ambiente Alimentar e de Saúde, Departamento de Nutrição, Universidade Federal de Minas Gerais (UFMG). Av. Alfredo Balena 190, Santa Efigênia. 30130-100 Belo Horizonte MG Brasil. brunavlcosta@gmail.com
[2] Grupo de Pesquisa em Alimentação e Nutrição, Faculdade de Nutrição, Universidade Federal de Alfenas. Alfenas MG Brasil.

Introduction

Almost one third of the total food production on the globe is discarded as food loss and/or waste (FLW)[1]. The recent report by the United Nations Environment Programme (PNUA) estimates that in 2019 around 931 million tons of food were wasted. This suggests that 17% of total global food production can be wasted[2]. Food loss (FL) refers to decrease in the amount and quality of the edible part of food produced for human consumption in the first three stages of the food supply chain (FSC), namely: production, post-harvest and processing, whereas food waste (FW) refers to the final stages of FSC: distribution/retail and consumption[1,3,4].

The amount of FLW varies between countries, since it is influenced by income, urbanization and economic growth level[5]. Food is mostly lost during production, post-harvest, processing and distribution in low-income countries, and the smallest fraction of it is wasted at consumer level[1,6].

Given such challenging scenario it is necessary to understand that FLW reduction strategies must be region-specific; they should be adapted to local situations (e.g., energy limitation, infrastructure limitation), and target FL, that occurs mainly in developing countries, and FW, that occurs in developed countries, in order to properly manage the several barriers[7].

FLW reduction is a priority in the global political agenda due to its impact on food security; natural environmental resources, mainly land, water, and energy; and human health[7,8]. The literature highlights the need of paying closer attention to countries Latin America, outside the United States and European countries, mainly to large developing countries and emerging economies, since they have less FLW information available, although, assumingly, they must account for large amounts of it[8,9].

The aim of the present scoping review is to better understand the FLW process in Latin American countries, considering the four stages (production, post-harvest, processing and distribution/retail) of the food supply chain (FSC) which are the stages of greatest loss in low-income countries[1,6]. Clearly understanding FLW is essential, given the scarcity of data about it in developing countries, mainly in Latin America[9,10]. This shall help organizing the few data available, identifying the existing gaps and observing the direct efforts to prevent and reduce FLW in Latin America. The goal is to answer the following questions:

- What is the FSC stage (production, post-harvest and processing, distribution/retail) accounting for the greatest food loss and food waste generation rates in Latin American countries?
- What are the economic, social, environmental factors influencing food loss and food waste generation in Latin American countries?
- What are the economic, social and environmental impacts of food loss and food waste generation on Latin American countries?

Methods

Scoping review of observational, case report and interventional studies about FW and FL in Latin American countries was carried out. Latin America is composed of 20 countries, namely: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Haiti, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, Uruguay and Venezuela. It recorded human development index of 0.766, back in 2019[11].

The current scoping review followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines and the recommendation in the Cochrane Handbook for Systematic Reviews of Interventions[12]. The SPIDER criteria (Sample, Phenomenon of Interest, Design, Evaluation and Research Type) were used to define the research question[13] (Chart 1).

We selected all studies that met the inclusion criteria for the conduction of the present study in January 2023.

Search Strategy

Searches were performed in the PubMed, EMBASE, SCOPUS, Web of Science, Agricola, EBSCO'S Academic Search Ultimate, Cab Direct databases. They concerned articles and the hand-searching of reference lists unpublished articles and thesis repositories were also used as data sources. Publication date and language were not used as exclusion criteria. The adopted keywords were food waste, food loss, garbage, waste management, food wastefulness, waste prevention, food wastage, food waste quantification, food waste reporting, amount of food waste. Search strategies used in each database are described in Chart 2.

Chart 1. SPiDER.

Sample	Latin American coutries
Phenomenon of interest	Stage of food supply chain analyzed; factors influence the loss (economic, social, environmental); economic, social and environmental impacts
Design	Observational studies (cross-sectional studies or ecological studies), case reports, interventional studies.
Evaluation	Food waste and Food lost
Research Type	Qualitative method

Source: Authors.

Chart 2. The search strategies.

PubMed
"Food Supply"[Mesh] OR ("Food Supply") OR ("food security") OR ("food insecurity") OR ("food supply chain") AND "LATIN AMERICA"[Mesh] OR "LATIN AMERICA" OR "Argentina"[Mesh] OR "Argentina" OR "Bolivia"[Mesh] OR "Bolivia" OR "Brazil"[Mesh] OR "Brazil" OR "Chile"[Mesh] OR "Chile" OR "Colombia"[Mesh] OR "Colombia" OR "Costa Rica"[Mesh] OR "Costa Rica" OR "Cuba"[Mesh] OR "Cuba" OR "Dominican Republic"[Mesh] OR "Dominican Republic" OR "Ecuador"[Mesh] OR "Ecuador" OR "El Salvador"[Mesh] OR "El Salvador" OR "Guatemala"[Mesh] OR "Guatemala" OR "Haiti"[Mesh] OR "Haiti" OR "Honduras"[Mesh] OR "Honduras" OR "Mexico"[Mesh] OR "Mexico" OR "Nicaragua"[Mesh] OR "Nicaragua" OR "Panama"[Mesh] OR "Paraguay"[Mesh] OR "Paraguay" OR "Peru"[Mesh] OR "Peru" OR "Uruguay"[Mesh] OR "Uruguay" OR "Venezuela"[Mesh] OR "Venezuela" OR "Mercosur" OR "Caribbean Netherlands" OR "Caribbean Region"
EMBASE
#5 #1 AND #2 AND #4 195 **#4** **'food chain'**/syn OR **'food system'**/syn OR **'food security'**/syn OR **'food insecurity'**/syn 33,464 **#3** **'food system'**/exp 16 **#2** **'waste and waste related phenomena'**/syn OR **'waste'**/syn OR **'agricultural waste'**/syn OR **'food waste'**/syn OR **'fruit and vegetable waste'**/syn OR **'vegetable waste'**/syn OR **'waste management'**/syn OR **'waste prevention'**/syn 507,561 **#1** **'south and central america'**/syn OR **'brazil'**/syn OR **'argentina'**/syn OR **'aruba'**/syn OR **'caribbean islands'**/syn OR **'bolivia'**/syn OR **'chile'**/syn OR **'colombia'**/syn OR **'ecuador'**/syn OR **'french guiana'**/syn OR **'guyana'**/syn OR **'netherlands antilles'**/syn OR **'paraguay'**/syn OR **'peru'**/syn OR **'suriname'**/syn OR **'uruguay'**/syn OR **'venezuela'**/syn OR **'central america'**/syn OR **'belize'**/syn OR **'caribbean'**/syn OR **'costa rica'**/syn OR **'el salvador'**/syn OR **'guatemala'**/syn OR **'honduras'**/syn OR **'nicaragua'**/syn OR **'panama'**/syn
SCOPUS
(TITLE-ABS-KEY ("LATIN AMERICA" OR "Argentina" OR "Bolivia" OR "Brazil" OR "Chile" OR "Colombia" OR "Costa Rica" OR "Cuba" OR "Dominican Republic" OR "Ecuador" OR "el salvador" OR "Guatemala" OR "Haiti" OR "Honduras" OR "Mexico" OR "Nicaragua" OR "Panama" OR "Paraguay" OR "Peru" OR "Uruguay" OR "venezuela" OR "Caribbean Netherlands" OR "Caribbean Region")) AND (TITLE-ABS-KEY ('food AND waste' OR 'garbage' OR 'food AND wastage' OR 'food AND waste AND quantification' OR 'food AND waste AND reporting' OR 'amounts AND of AND food AND waste' OR 'waste AND management' OR 'food AND wastefulness' OR 'waste AND prevention' OR 'food AND loss' OR food AND losses' OR 'food AND loss' OR 'food AND losses AND food AND waste')) AND (TITLE-ABS-KEY ("Food Supply" OR "food security" OR "food insecurity" OR "food supply chain"))

it continues

Chart 2. The search strategies.

Web of Science	
# 4	#3 AND #2 AND #1
	Índices=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Tempo estipulado=Todos os anos
# 3	TS=("LATIN AMERICA" OR "Argentina" OR "Bolivia" OR "Brazil" OR "Chile" OR "Colombia" OR "Costa Rica" OR "Cuba" OR "Dominican Republic" OR "Ecuador" OR "El Salvador" OR "Guatemala" OR "Haiti" OR "Honduras" OR "Mexico" OR "Nicaragua" OR "Panama" OR "Paraguay" OR "Peru" OR "Uruguay" OR "Venezuela" OR "Mercosur" "Caribbean Netherlands" OR "Caribbean Region") *Índices=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Tempo estipulado=Todos os anos*
# 2	TS=("Food Supply" OR "food security" OR "food insecurity" OR "food supply chain") *Índices=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Tempo estipulado=Todos os anos*
# 1	TS=('food waste' or 'garbage' or 'food wastage' or 'food waste quantification' or 'food waste reporting' or 'amounts of food waste' or 'waste management' or 'food wastefulness' or 'waste prevention' or 'food loss' or food losses' or 'food loss' or 'food losses and food waste') *Índices=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Tempo estipulado=Todos os anos*
AGRICOLA	
Keyword Anywhere(food waste) OR food loss)) AND Keyword Anywhere(Latin america))	
EBSCO AS primer	
('food waste' or 'garbage' or 'food wastage' or 'food waste quantification' or 'food waste reporting' or 'amounts of food waste' or 'waste management' or 'food wastefulness' or 'waste prevention' or 'food loss' or food losses' or 'food loss' or 'food losses and food waste') AND ("Food Supply" OR "food security" OR "food insecurity" OR "food supply chain") AND ("latin america" OR "argentina" OR "bolivia" OR "brazil" "chile" OR "colombia" OR "costa rica" OR "cuba" OR "dominican republic" OR "ecuad OR " OR "el salvador" OR "guatemala" OR "haiti" OR "honduras" OR "mexico" OR "nicaragua" OR "panama" OR "paraguay" OR "peru" OR "uruguay" OR "venezuela" OR "mercosur" OR "caribbean netherlands" OR "caribbean region")	
CABI	
((("latin america") OR ("argentina") OR ("bolivia") OR ("brazil") OR ("chile") OR ("colombia") OR ("costa rica") OR ("Cuba") OR ("dominican republic") OR ("ecuador") OR ("el salvador") OR ("guatemala") OR ("haiti") OR ("honduras") OR ("mexico") OR ("nicaragua") OR ("panama") OR ("paraguay") OR ("peru") OR ("uruguay") OR ("venezuela") OR ("mercosur") OR ("caribbean netherlands") OR ("caribbean region"))) AND ((("Food Supply") OR ("food security") OR ("food insecurity") OR ("food supply chain"))) AND (('food waste') OR (garbage) OR ("food wastage") OR ('waste management') OR ('food wastefulness') OR ('waste prevention') OR ('food losses') OR ('food loss'))	

Source: Authors.

Inclusion criteria

Observational studies, case reports and interventional studies about food loss and food waste generation were used to quantify and assess factors influencing the impacts of destiny and initiatives to reduce FLW in Latin American countries. Comments and general reviews were excluded from the search, in the first moment.

Articles' selection, data-collection process and data items

Titles and abstracts were read, in duplicate, by two appraisers (BVLC and NGC) in order to apply the inclusion criteria – disagreements were solved by consensus. The ENDNOTE X9 software was used in titles and abstracts' reading.

Data were independently extracted in duplicate by two appraisers (BVLC and NGC). Data included year when the study was performed and reported; language; study design; location of study; food under study; food supply chain stage when the greatest loss was recorded; FLW amount; FLW influence factors; economic, social and environmental impacts; FLW destination and initiatives to reduce FLW in Latin American countries.

We adapted the instrument to assess the quality of articles, Newcastle-Ottawa (NOS), as we did not find a specific instrument suitable for our type of study. However, two authors (BVLC and NGC) have assessed only three relevant article-quality domains: a) using validated measurement tool or secondary data (Selection section - item 4), b) clearly and properly describing the

statistical test for data analysis (Outcome section - item 2), c) complete results consistent with the methodology (Comparability section). For each domain, 1 point was assigned, with the final score corresponding to the general quality of the article. Thus, score 1 refers to low quality (adequacy in only one domain) and score 3 attributes better methodological quality (adequacy in all three domains). Differences in data quality assessment scores, seen as uncommon between appraisers, were solved by consensus, or by a third author.

Results and discussion

In total, 1,464 citations were identified in the assessed databases (Figure 1). After titles and abstracts' reading, 25 references were considered eligible for the review; therefore, they were read in full. We added four articles found through the hand-searching of reference lists to the sample. Unpublished articles and thesis were not found. In total, 16 articles[1,14-28] met the inclusion criteria, so they were included in the present scoping review.

The features of the selected studies are shown in Chart 3. Fourteen (14) of the 16 eligible articles had followed the cross-sectional design, two

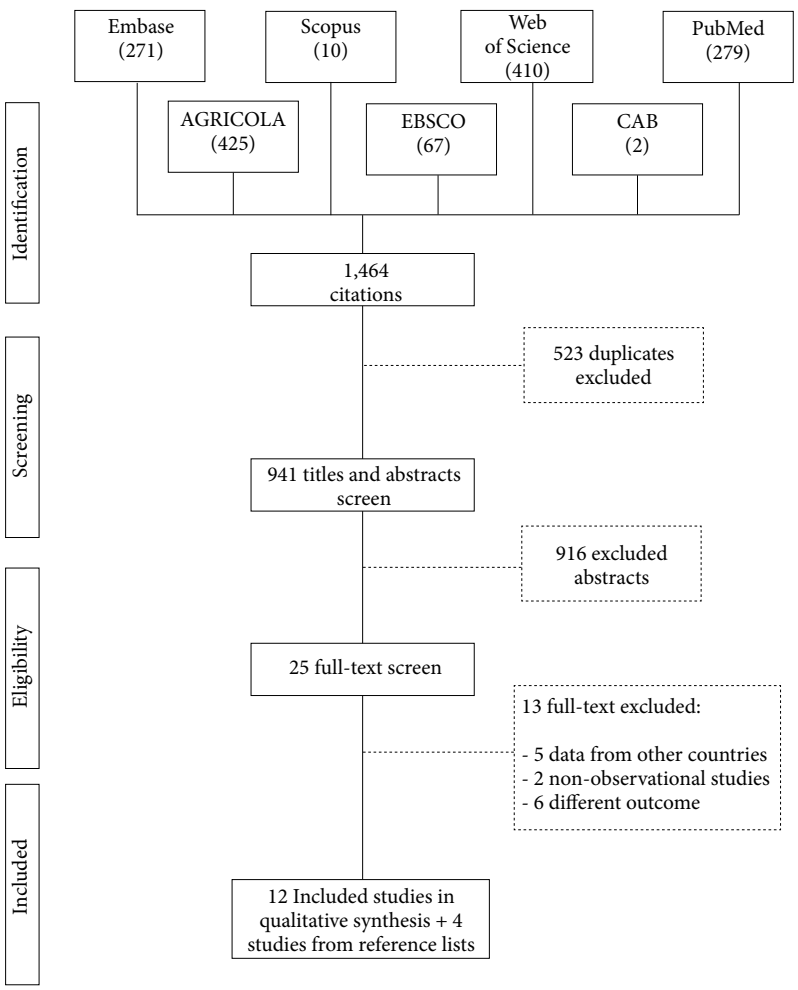

Figure 1. PRISMA flow chart for article selection.

Source: Authors.

Chart 3. Characteristics of included studies.

FLW	Author, year	Language	Study design	Study location	Stage of the FSC*	Food	Study Quality***
Food Loss	Mendonza *et al.*, 2017[13]	English	Cross-sectional	Guatemala. Western highlands	Post-harvest handling and storage	Maize	1
	Quellhorst *et al.*, 2020[14]	English	Cross-sectional	Haiti. Ouest, Centre, and lower Artibonite	Post-harvest handling and storage	Maize, beans	2
	Conte *et al.*, 2020[16]	Portuguese	Cross-sectional	Brazil - Paraná	Harvest and postharvest	Soybean	2
	Arends-Kuenning *et al.*, 2022[15]	English	Cross-sectional	Brazil - Paraná	Harvest and postharvest	Soybean	2
Food Waste	Jica, 2013[17]	English	Cross-sectional	Colombia - Bogotá	Distribution	Meals	3
	Santos *et al.*, 2020[18]	English	Cross-sectional	Brazil - Bahia - Salvador	Distribution	Fruits and Vegetables	3
	Silva *et al.*, 2021[19]	English	Cross-sectional	Brazil - Rio de Janeiro	Distribution	Food	3
Food Loss and Waste	Gustavsson *et al.*, 2011[1]	English	Cross-sectional	Latin America	FSC	Cereals, roots and tubers; Pulses; Fruits and vegetables; meat; fish and seafood; milk	3
	Delgado *et al.*, 2017[20] Delgado *et al.*, 2021[21]	English	Cross-sectional	Ecuador, Peru, Honduras, Guatemala	FSC	Potato, beans, maize	3
	CEC, 2017[22]	English	Cross-sectional	Mexico	FSC	Food	3
	Chaboud, 2017[23] Chaboud and Moustier, 2021[24]	English	Case report	Colombia - Cali	FSC	Tomatoes	2
	Dal'Magro and Talamini, 2019[25]	English	Case report	Brazil - NI - NI**	FSC	Cereals, roots and tubers; Pulses; Fruits and vegetables; meat; fish and seafood; milk	2
	Velasco *et al.*,2019[26]	Spanish	Cross-sectional	Ecuador, Peru	FSC	Potato	2
	Bedoya-Perales and Dal Magro, 2021[27]	English	Cross-sectional	Peru	FSC	Fruits and vegetables, roots and tubers, fish and seafood	3

*FSC: Food supply chain, **NI: Not informed, ***Quality studies.

Source: Authors.

of them were case reports - no interventional trial was identified. Five (5) of the selected studies had evaluated Brazilian data[16,17,19,20,26], and the others referred to studies carried out in Guatemala (n=1)[14], Haiti (n=1)[16], Colombia (n=3)[18,24,25], Mexico (n=1)[23], Peru (n=1)[28], Ecuador and Peru (n=1)[27], Ecuador, Peru, Honduras and Guatemala (n=2)[21,22], and Latin America (n=1)[1]. Farmers

Chart 4. Food loss: results on each individual study of the scoping review.

Author, year	Data of food loss	Factors influence the food loss	Impacts, destiny and initiatives to reduce food loss
Mendonza *et al.*, 2017[13]	Farmers (producers): FL was 6.6% a total production during storage. Farmers (purchaser): FL was 1.5% a total production during storage	Excessive humidity or mishandling of moisture in the grain, rodents, rot, grain and environmental moisture, fungal, birds and insects	*Destiny*: for animals and human consumption *Initiatives to reduce*: drying, control of pest focusing on rodent, moth and weevil control mostly (pastilla – pill – of a phosphine or phosphamine salt)
Quellhorst *et al.*, 2020[14]	FL occurs during storage for 86.6% of farmers	Rodents, insects, moisture, birds and other animals, theft	*Initiatives to reduce*: use of chemical control and natural products to manage pests
Conte *et al.*, 2020[16]	Average harvest loss of 1.05 bags (60 kilogram bags) per hectare	Time of experience with soybean cultivation in the region, topographically less favorable areas for production, outsourcing of harvesting Time of use of harvesting machines	*Initiatives to reduce*: innovative technologies employed in harvesting machines, wider platforms, training workers to master the adjustments and maintenance
Arends-Kuenning *et al.*, 2022[15]	Harvesting and storage are the most important stage where loss happens Perceived amount of harvest loss: farmers who hire others (120 kg per hectare or 0.03 percent of total production) farmers who harvest by themselves (88 kg per hectare or 0.02 percent of total production)	Training of the combine operator Person responsible for the harvest: farmers harvested the land by themselves or asked others to do so Farmers' education level Moisture level Land size	*Initiatives to reduce*: to own and operate their own equipment, to provide resources for farmers to be able to harvest their own land by themselves, training for farmers to improve knowledge and skills, monitoring of the combine operators and better monitoring system when others harvest

Source: Authors.

and traders (n=9)[1,21-28]; only farmers (n=4)[14-17] or only traders (n=3)[18-20] were respondents in the selected articles. Most studies have evaluated the entire food supply chain (n=9)[1,21-28], three of them assessed the distribution[18-20] and four studies focused on post-harvest handling and storage[14-17]. The individual quality of the assessed studies ranged from 1 to 3 (Chart 3). Only seven studies (43.7%) presented better methodological quality, demonstrating the need for more robust studies with reliable and rigorous methodology to produce scientific evidence on the topic.

Results recorded in the selected studies were organized based on food loss and food waste concepts due to deterioration and losses at production level and to deterioration at distribution/retail[1,6]. Chart 4 presents results in primary studies about food losses at initial FSC stages, Chart 5 shows results recorded for food waste at distribution and Chart 6 presents food loss and waste at all FSC stages.

Based on Charts 4 and 6, the total number of 13 selected studies reported food loss[1,14-17,21-28]. One study evidenced 2,220 kg/year of food loss *per capita* in Latin America[1]. Eleven studies mentioned food losses at food supply chain's early and middle stages [1,14-17,21,22,24-28], mainly during storage[14,15,17,26-28]. The study carried out in Peru and Ecuador showed major food loss frequency at food production, before harvest (>70%)[27]. The Colombian studies showed FLW higher in farms (58%) than in trade (22%) and retail establishments (25%), but FLW rates tended to be concentrated in few cultures - tomatoes' FLW reached 11.2%, on average)[24,25]. The largest FLW rates in Peru were related to farm size; smaller farms accounted for higher food loss rates[27].

Food commodities with the highest loss rates encompass fruits and vegetables, roots and tubers, and cereals[1,26,28].

The main food loss cause reports concerned financial, managerial and harvesting technique

Chart 5. Food loss: results on each individual study of the scoping review.

Author, year	Data of food waste	Factors influence the food waste	Impacts, destiny and initiatives to reduce food waste
Jica, 2013[17]	Average of the production of solid waste: by small commercial producers is 1.36 Kg/ establishment/day	NI*	*Initiatives to reduce:* separate recyclable waste, donation recyclable resources (cardboard, paper, and plastics), program for collecting recyclables, publicize the concept of 3R: reduce (resource consumption), reuse (what can be reused), and recycle (recycle what cannot be reused as raw material).
Santos *et al.*, 2020[18]	14.24% of all purchases was discarded weekly The highest of losses were bananas, papayas, tomatoes and peppers	Natural deterioration, lack of specific conservation, storage facilities and excessive customer handling. In the stands the recently arrived fruits and vegetables were placed on top of the ones that were already in place and lack of order in the replacement of old products contributed to increased losses. Conditions of the vehicles used to transport fruits and vegetables had inadequate hygiene and refrigeration. The reception and packaging practices were inadequate.	*Destiny:* donation to organizations or economically vulnerable individuals (35%) or consumption by the sellers and their families (9%). *Initiatives to reduce:* packing products carefully, to cover/protect, watering the green leafy vegetables throughout the day, requesting only the necessary supply, keeping the workplace clean
Silva *et al.*, 2021[19]	The higher percentages of loss were fruits and vegetables, fishmonger, butchery, and bakery. The overall average loss rate reached 8.9% of gross revenue.	An operational breakdown External theft and internal theft Administrative errors	*Initiatives to reduce:* discounts on products reaching their expiry dates, having a loss prevention department, strict quality control for the reception of products, audits, minimum stock, efficient handling of products, staff training, preference for local suppliers, the use of processing and packaging technologies, inventory turnover between stores, raising awareness of customers regarding the handling of products, to send recyclable material to recycling institutions, donation food before the expiry date (food banks), production of biogas through anaerobic digestion, incineration with energy recovery, generation of new products (conversion of organic waste into fertilizer)

*NI: not informed.

Source: Authors.

limitations; storage and difficult climatic conditions; as well as poor infrastructure, and packaging and marketing systems [1,15,16,20,21,22,26,27]. The main factors influencing such losses in the selected studies were climatic factors, excessive humidity; as well as the presence of rodents, fungi, birds and insects; and low seed quality[14,15,17,21,22,24-28]. One of the selected studies mentioned theft as one of the causes of food loss[15].

According to farmers, losses are caused in small food (potatoes, for example) during harvest, mechanical damage due to mistaken hoe using, low market price, lack of manpower, and inexperienced employees. Losses during harvest are caused by poor quality of food (potatoes, for example) inserted into the bags, hit during transportation or food that is accidentally smashed during separation. Losses at the storage stage

Chart 6. Food loss and waste: results on each individual study of the scoping review.

Author, year	Data of food loss and waste	Factors influence the food loss and waste	Impacts, destiny and initiatives to reduce food loss and waste
Gustavsson *et al.*, 2011[1]	FL was 2220kg/per capita/per year in Latin America and occurs in the early and middle stages of the FSC. Estimated waste percentages: Cereals: 17% (FL); 14% (FW); Roots and tubers: 40% (FL); 7% (FW); Oilseeds and pulses: 17% (FL); 4%(FW); Fruits and vegetables: 50% (FL); 22% (FW); Meat: 11,4% (FL); 11% (FW); Fish and seafood: 19,7% (FL); 14% (FW); Milk:11,5% (FL); 12% (FW)	Financial, managerial and technical limitations in harvesting techniques, storage and cooling facilities in difficult climatic conditions, infrastructure, packaging and marketing systems	NI
Delgado *et al.*, 2017[20] Delgado *et al.*, 2021[21]	Loss fluctuates between 6 and 25% of total production and of the total produced value. Loss at the producer level (60 to 80%) of the total value chain loss; at the middleman (7%) and processor levels (19%).	Pests and diseases, lack of harvesting techniques, lack of training and experience in selecting the produce, post-harvest activities, lack of storage facilities and efficient transport systems	Use of improved seeds
CEC, 2017[22]	FLW was 28 million tonnes by year in Mexico: Pre-harvest: 9 million tonnes Post-harvest: 5 million tonnes Processing: 5 million tonnes Distribution: 5 million tonnes FLW is 249 kilograms/person/year in Mexico: Pre-harvest: 83 kilograms Post-harvest: 44 kilograms Processing: 45 kilograms Distribution: 40 kilograms	Overproduction by processors, wholesalers and retailers, product damage, lack of cold-chain infrastructure (refrigeration during transportation and storage), rigid food-grading specifications, varying customer demand, market fluctuations	*Impacts (per year):* Life-Cycle Greenhouse Gas Emissions for Landfilled FLW: 49 million tonnes CO2; Fertilizer Use: 0.63 million tonnes; Water use 2.7 billion m3; Wasted Cropland: 4.4 million ha; Energy Use: 3.4 1018 Joules *Initiatives to reduce:* reducing portion sizes, increasing marketability, standardizing date labels, packaging adjustments, improving cold-chain management, financial incentives for food donation, online food rescue platforms, feeding animals
Chaboud, 2017[23] Chaboud and Moustier, 2021[24]	FLW are higher at farm stage: farmers (58%), traders (22%) and retailers (25%). The average rate of FLW was 0.5% per trader and 1.7% per retailer. Producers: 10% report a FLW of at least 32.1% while 5% lose more than 55.6% of the tomatoes harvested. Retailers: 5% declare that they throw away at least 10% of tomatoes purchased, while 81% of the respondents throw away less than 2%.	Diseases and pests	*Destiny*: own consumption and donation *Initiatives to reduce:* pest and disease control at pre- and post-harvest stages

it continues

often happen due to the presence of moth and insects in the storage area. Retailers and wholesalers state that food losses are caused by mechanical damage to the product[27].

Chart 6. Food loss and waste: results on each individual study of the scoping review.

Author, year	Data of food loss and waste	Factors influence the food loss and waste	Impacts, destiny and initiatives to reduce food loss and waste
Dal'Magro and Talamini, 2019[25]	Agricultural production (AP) (26.26%) and processing and packaging (PP) (24.67%): of fruits and vegetables, roots and tubers and cereals. In the 2007 the FLW was 77.7 million tons: AP (20.4 million) and PP (19.2 million). Between 2007 and 2013 was 82.1 million tons per year: AP (21.1 million) and PP (19.8 million). Distribution and consumption: larger quantities of fruits and vegetables, cereals and milk.	NI	*Initiatives to reduce:* donation for food banks, modernization of the supply centers, research related to pest management, agroindustrialization and food processing, post-harvest practices, packaging, logistics and waste disposal, public purchases of food from family farming
Velasco *et al.*,2019[26]	Producers reported losses in Peru (82.5%) and in Ecuador (85.0%). In Peru the FL was: before the harvest (71.98%), left in the field (34.81%), during the harvest (50.74%), during selection (14.45%), during storage (10.62%). In Ecuador the FL was: before the harvest (71.59%), left in the field (19.45%), during the harvest (61.86%), during selection (16.34%), during storage (3.11%). In Peru, FLW differences depending on the size of the farm.	In Peru: climatic factors, with a lack of rain and frostspoor quality, mechanical damage and moth, insects. In Ecuador: climate, insects and poor seed quality, mechanical damage, excessive humidity (storage), attack of moths.	NI
Bedoya-Perales and Dal Magro, 2021[27]	12.8 million tonnes of FLW per year: mostly was during the pre-consumption steps (10.8 million tonnes per year). During the period 2007–2017, in Peru was 3.3 million tonnes in agricultural production, 2.3 million tonnes in post-harvest handling and storage, 3.5 million tonnes in processing and packaging, 1.7 million tonnes in distribution. The group of fruits and vegetables, with roots and tubers, contributed 65.13% of the total FLW flow. The groups of cereals and fish totaled 28.07%, and the group of pulses, meat, and milk represented 6.8% of FLW.	Unfavorable climatic conditions, pests, diseases, lack of cold chain logistics, bad harvest technique and lack of labor, the market inconsistency	*Initiatives to reduce: t*o innovation in short food supply chains and short marketing circuits, valorization of food manufacturing waste, intelligent food logistics and supply chain planning, marketing infrastructure for farmers

*NI: not informed.

Source: Authors.

One of the selected studies showed that donation was practiced by 72% of farmers, 69% of traders and 44% of retailers. Home-consumption is retailers' second favorite option to avoid the disposal of unmarketable food. Farmers and traders never use food waste for home-consumption[24].

One study suggested 1) food waste donations to food banks; 2) modernizing supply centers to mitigate food losses due to infrastructure constraints; 3) developing research related to pest management, agro-industrialization and food processing, post-harvest practices, packaging, logistics and waste disposal; 4) carrying out public food purchases from family farms, such as the Food Acquisition Program and the National School Feeding Program, as strategies to reduce FL[26].

None of the selected studies presented results about the FL impact on Latin American countries.

Based on Charts 5 and 6, food waste was reported in 12 studies[1,18-28]. Three studies assessed the only distribution stage[18-20]. The rate of purchased food discarded on a weekly basis reached 14.24%, it was mainly observed for banana, papaya, tomato and pepper[19,20,26].

Fruits and vegetables are lost due to natural food deterioration, since it is accelerated by lack of specific conservation procedures, poor storage facilities, excessive customers' food handling and by inadequate material management (inappropriate replacement and vehicles' poor transport conditions)[19,20]. This authors also pointed out that food waste is also related to purchased food volume and farm income; higher income results in buying higher volumes of food and, consequently, in greater losses[19].

The other factors influence the FW was lack of appropriate storage facilities and efficient transport systems, varying customer demand, market fluctuations, market systems (diversity of supply channels in formal and informal food chains)[21-23,28].

The studies showed to initiatives to reduce FW such as separating recyclable waste, donating recyclable resources, carefully packaging products, ordering only what is necessary, keeping the workplace clean, strict quality control when receiving products, team training, preference by local suppliers and the use of processing and packaging technologies[18-20]. One study cited biogas production through anaerobic digestion, incineration with energy recovery, generation of new products (conversion of organic waste into fertilizer)[20].

Only one study cited the impact of FLW in greenhouse gas emissions for landfilled, fertilizer use, biodiversity loss, water and energy use[23].

Similar in Latin America countries, the largest amount of FLW in Turkey is generated in the initial steps of the FSC. But in Turkey the mostly FLW concentrated in the agricultural production step. This process generates loss of approximately 13.7 million tons, and it corresponds to 11.9% of the total food produced in Turkey[29,30]. The main reasons reported for FLW were lack of cooperation, using traditional methods, rejection to new agricultural knowledge and technologies, using fertilizers and pesticides, damage to crops (tuber cutting, early uprooting, among others) and poor storage conditions[29].

In the Sub-Saharan Africa (SSA) the estimates for all food lost is roughly 37% the total of produced food, or 120-170 kg/year *per capita*[31]. There is consensus that it mostly happens in SSA at the middle FSC stages. Grains and cereals are lost during post-harvest handling and storage in farm, whereas fresh products, meat and seafood losses mainly happen at the processing, packaging and distribution stages in SSA[1,32,33].

In the United States (USA), the biggest FSC losses happen at the middle FSC stages, mainly at the food handling and processing stages (15%). However, higher FW values were observed at consumer level – it reached 21%. Based on these results, food is lost at early FSC stages or wasted at the final consumer stage, in the USA[34].

It is important to highlighting the impossibility of comparing findings in the selected studies, because there was no data standardization. It was not only difficult comparing values due to included crop differences, value chain levels, scales, agroecologies, seasonality and geography, but also because of the often unsatisfactory adopted methodologies[31,35].

Furthermore, FLW data were relatively underexplored and recorded, mainly in Latin American studies[10]. In total, 11 of the 20 Latin American countries did not have a single research on FLW. Brazil stood out for being the most productive country in terms of scientific research on this topic among the nine countries with publications in this field.

Such a shortage in research development on FLW in Latina American countries is similar to that observed for the Arabian world[36]. The main factors justifying this scarcity of articles lies on lack of interest by local scientists in the subject; on the small number of local scientists in the FLW field, and on lack of governmental funding and support[36]. It is noteworthy that no attention was paid to other FSC stages, such as production before harvest, processing and packaging.

Assumingly, there is no consensus on the golden methodology to evaluate FLW[37], since all methodologies available present some limita-

tions[4]. Methodologies range from modeling/simulation to direct observation, to residual methods. All these methodologies are suitable when they are appropriately used, but they can be easily misused and misinterpreted[31].

Lack of standardized measurement protocols associated with data scarcity leads to widely varying FLW estimates in the international literature, as well as to uncertainties about the estimated volumes[2,38]. However, FLW quantification is only the first step allowing the best understanding about how much, why and where FLW happens[8,24]. And the report by the United Nations Environment Programme (PNUA) published in 2021 presents a methodology for countries to quantify food waste at the level of households, food services and food trade[2].

It is important measuring food losses or waste generation, at each FSC stage, for managerial purposes[1]. Better data measuring and monitoring aim at helping to better understand the social, economic and environmental impacts of FLW, at identifying the hotspots where actions should be prioritized, at developing long-term scenarios to inform relevant policy-making, at understanding what policies and strategies have been most-effective at achieving FLW reduction and at, overall, contributing to FLW reduction and to food system sustainability[8].

One of the main results of this literature review lies on the low expressiveness, or lack, of studies introducing and discussing the economic, environmental and social impacts of food loss and waste. Food losses represent the waste of production resources such as land, water, energy and inputs[39].

FAO quantified the food wastage footprint on natural resources and showed that total carbon footprint of food wastage, including land use change, is around 4.4 $GtCO_2$ eq per year. The carbon footprint of a food product is the total amount of GHG emitted throughout its lifecycle, expressed in kilograms of CO_2-equivalents[40]. It should be noted that producing food that will not be consumed leads to unnecessary CO_2 emissions, in addition to food economic value loss. In addition, economically avoidable food losses have direct, and negative impact, on both farmers and consumers' income; these people can live on the margins of food insecurity. Moreover, food loss reduction could have immediate and significant impact on the livelihood of these populations[39].

Reducing FLW is crucial and it can contribute to higher efficiency and yield of water, land and nutrient resources, as well as lead to a more environmentally sustainable agricultural production and consumption system[7]. Source reduction and prevention strategies are the favorite methods to achieve FLW reduction.

Other potential solutions include feeding people in food banks and other donation programs, using animal feed, industrial use of food waste such as fuel rendering and conversion, using it for composting, and finally (as last resort) discharging it in landfills or using it in incinerators[39].

Other preventive actions need to be considered, namely: avoiding food overproduction or surplus at production and consumption stages; preventing avoidable waste generation by means of the food value chain; providing knowledge and information to consumers and educating them about the monetary value of environmental food–waste externalities; educating individuals and do community interventions to ensure "cascade training"; and allocating production surpluses through redistribution networks, institutions and food banks to people who are facing food insecurity[7]. Education is related to prevention methods that act directly to change the behaviors, mindsets, and awareness of all involved in the food chain[41].

However, there must also be governmental actions for the implementation of programs and public policies aimed at reducing the FWL through the establishment of goals and mitigation of factors that cause waste. The implementation of policies is an efficient way to involve the different actors in the FSC because it forces them to prioritize the prevention and minimization of FWL in their business. These policies need to be inspected and supervised to ensure compliance with the guidelines[41].

Potential limitations of this review should be taken into consideration. The main expressive terms of the theme were not indexed. Although a wide search was performed, with no language or time-related limits, a small number of articles about FLW was found. The shortage of articles may reveal that the subject has not yet been the subject of studies, involving the adoption of different designs and strategies. Most studies were carried out in Brazil; therefore, most results only represent the Brazilian FLW. The scarcity of studies on FLW available in scientific databases[24] points towards low investment in research focused on this topic, mainly in Latin American countries[10]. Thus, understanding how much, why and where FLW takes place may be greater than the one found in this study.

Despite of mentioned limitations, the current study has several strengths, such as using a rigorous methodology based on PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines; providing a comprehensive literature search that encompassed seven electronic databases (PubMed, EMBASE, SCOPUS, Web of Science, Agricola, EBSCO'S Academic Search Ultimate, Cab Direct); search, selection and data extraction in separate, and in duplicate, by two researchers, based on third-party disagreement solution; and presenting well-defined inclusion criteria that have prioritized studies focused on FLW in Latin American countries.

Conclusion

In conclusion, Latin American countries account for high rates of food loss, which is featured by decreased amount and quality of food in the first three FSC stages, mainly during storage. The main causes of FSC in these countries are related to financial, managerial and operational limitations during food collection, storage and refrigeration.

Collaborations

BVL Costa: conceptualization; data curation; formal analysis; writing – original draft; writing – review & editing. NG Cordeiro: data curation; formal analysis; writing – original draft; writing – review & editing. VB Bocardi: data curation; formal analysis; writing – original draft; writing – review & editing. GR Fernandes: formal analysis; writing – original draft; writing – review & editing. SCL Pereira: formal analysis; writing – original draft; writing – review & editing. RM Claro: formal analysis; writing – original draft; writing – review & editing. CK Duarte: conceptualization; data curation; formal analysis; writing – original draft; writing – review & editing.

Acknowledgments

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001.

References

1. Gustavsson J, Cederberg C, Sonesson U. *Global food losses and food waste* [Internet]. 2011 [cited 2022 nov 4]. Available from: https://www.fao.org/3/i2697e/i2697e.pdf.
2. United Nations Environment Programme. *Food Waste Index Report 2021*. Nairobi: United Nations Environment Programme; 2021.
3. Food and Agriculture Organization of the United Nations (FAO). *Definitional Framework of Food Loss* [Internet]. 2014 [cites 2022 out 15]. Available from: https://www.fao.org/3/at144e/at144e.pdf.
4. Ishangulyyev R, Kim S, Lee SH. Understanding Food Loss and Waste–Why Are We Losing and Wasting Food? *Foods* 2019; 8:297.
5. Chalak A, Abou-Daher C, Chaaban J, Abiad MG. The global economic and regulatory determinants of household food waste generation: A cross-country analysis. *Waste Management* 2016; 48:418-422.
6. Food and Agriculture Organization of the United Nations (FAO). *Food wastage footprint: impacts on natural resources: summary report* [Internet]. Rome: FAO; 2013 [cited 2022 out 15]. Available from: https://www.fao.org/3/i3347e/i3347e.pdf.
7. Shafiee-Jood M, Cai X. Reducing Food Loss and Waste to Enhance Food Security and Environmental Sustainability. *Environ Sci Technol* 2016; 50:8432-8443.
8. Xue L, Liu G, Parfitt J, Liu X, Van Herpen E, Stenmarck Å, O'Connor C, Östergren K, Cheng S. Missing Food, Missing Data? A Critical Review of Global Food Losses and Food Waste Data. *Environ Sci Technol* 2017; 51:6618-6633.
9. Fabi C, Cachia F, Conforti, P, English A, Moncayo JR. Improving data on food losses and waste: from theory to practice. *Food Policy* 2021; 98:101934.
10. Kitinoja L, Kader AA. Measuring postharvest losses of fresh fruits and vegetables in developing countries. *PEF White Pap* 2015; 15:26.
11. Conceição P. Human Development Report 2020. The next frontier Human development and the Anthropocene [Internet]. [cited 2022 out 15]. Available from: http://hdr.undp.org/sites/default/files/hdr2020.pdf.
12. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA, editors. *Cochrane Handbook for Systematic Reviews of Interventions*. 2ª ed. Chichester: John Wiley & Sons; 2019.
13. Methley AM, Campbell S, Chew-Graham C, McNally R, Cheraghi-Sohi S. PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Serv Res* 2014; 14:579.
14. Mendoza JR, Sabillón L, Martinez W, Campabadal C, Hallen-Adams HE, Bianchini A. Traditional maize post-harvest management practices amongst smallholder farmers in Guatemala. *J Stored Products Res* 2017; 71:14-21.
15. Quellhorst HE, Njoroge A, Venort T, Baributsa D. Postharvest Management of Grains in Haiti and Gender Roles. *Sustainability* 2020; 12:4608.
16. Arends-Kuenning M, Garcias M, Kamei A, Shikida PFA, Romani GE. Factors associated with the harvest and postharvest loss among soybean farmers in Western Paraná State, Brazil. *Food Policy* 2022; 112:102363.
17. Conte O, Possamai EJ, Filho Cecere P. *Resultados do monitoramento integrado da colheita da solja na safra 2019/2020 no Paraná* [Internet]. 2020 [acessado 2023 mar 15]. Disponível em: https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1130138/resultados-do-monitoramento-integrado-da-colheita-da-soja-na-safra-20192020-no-parana.
18. Japan International Cooperation Agency (JICA). *2013 Project on Master Plan Study for Integrated Solid Waste Management in Bogota, D.C. Final Report* [Internet]. [cited 2023 mar 15]. Available from: https://openjicareport.jica.go.jp/pdf/12126835.pdf.
19. Santos SF, Cardoso RCV, Borges ÍMP, Almeida AC, Andrade ES, Ferreira IO, Ramos LC. Post-harvest losses of fruits and vegetables in supply centers in Salvador, Brazil: Analysis of determinants, volumes and reduction strategies. *Waste Management* 2020; 101:161-170.
20. Silva DEW, César AS, Conejero MA. Prevention of food waste and alternative destinations for unused food in Brazil. *J Cleaner Production* 2021; 318:128545.
21. Delgado L, Schuster M, Torero M. *The Reality of Food Losses a New Measurement Methodology* [Internet]. IFPRI; 2017 [cited 2023 mar 15]. Available from: https://www.oneplanetnetwork.org/sites/default/files/the_reality_of_food_losses_a_new_measurement_methodology.pdf.
22. Delgado L, Schuster M, Torero M. Quantity and quality food losses across the value Chain: A Comparative analysis. *Food Policy* 2021; 98:101958.
23. Commission for Environmental Cooperation (CEC). *Characterization and Management of Food Loss and Waste in North America*. Montreal: CEC; 2017.
24. Chaboud G. Assessing food losses and waste with a methodological framework: Insights from a case study. *Resources Conservation Recycling* 2017; 125:188-197.
25. Chaboud G, Moustier P. The role of diverse distribution channels in reducing food loss and waste: The case of the Cali tomate supply chain in Colombia. *Food Policy* 2021; 98:101881.
26. Dal' Magro GP, Talamini E. Estimating the magnitude of the food loss and waste generated in Brazil. *Waste Manag Res* 2019; 37:706-716.
27. Velasco C, Ordinola M, Devaux A. Una aproximación a la medición de pérdidas de alimento en la cadena de la papa en Ecuador y Perú. *Rev Latinoam Papa* 2019; 23(2):46-65.
28. Bedoya-Perales NS, Dal'Magro GP. Quantification of food losses and waste in Peru: A Mass flow analysis along the Food Supply Chain. *Sustainability* 2021; 13:2807.
29. Tatlıdil PFF, Dellal İ, Bayramoğlu Z. *Food Losses and Waste in Turkey* [Internet]. 2013 [cited 2021 nov 4]. Available from: https://www.fao.org/publications/card/en/c/274dfc13-7c02-428c-9ae7-e81724dfbfcc/.
30. Salihoglu G, Salihoglu NK, Ucaroglu S, Banar M. Food loss and waste management in Turkey. *Bioresour Technol* 2018; 248(Pt A):88-99.
31. Sheahan M, Barrett CB. Review: Food loss and waste in Sub-Saharan Africa. *Food Policy* 2017; 70:1-12.

32. Hodges RJ, Buzby JC, Bennett B. Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use. *J Agricult Sci* 2011; 149:37-45.
33. World Bank. *Missing Food: The Case of Postharvest Grain Losses in Sub-Saharan Africa* [Internet]. 2011 [cited 2021 nov 4]. Available from: https://openknowledge.worldbank.org/handle/10986/2824.
34. Dou Z, Ferguson JD, Galligan DT, Kelly AM, Finn SM, Giegengack R. Assessing U.S. food wastage and opportunities for reduction. *Global Food Security* 2016; 8:19-26.
35. Affognon H, Mutungi C, Sanginga P, Borgemeister C. Unpacking postharvest losses in Sub-Saharan Africa: a meta-analysis. *World Development* 2015; 66:49-68.
36. Abiad MG, Meho LI. Food loss and food waste research in the Arab world: a systematic review. *Food Sec* 2018; 10:311-322.
37. Lipinski B, Hanson C, Lomax J, Kitinoja L, Waite R, Searchinger T. *Reducing Food Loss and Waste. Working Paper, Installment 2 of Creating a Sustainable Food Future* [Internet]. Washington, D.C.: World Resources Institute; 2013 [cited 2021 nov 4]. Available from: http://www.worldresourcesreport.org.
38. Parfitt J, Barthel M, Macnaughton S. Food waste within food supply chains: quantification and potential for change to 2050. *Philos Trans R Soc Lond B Biol Sci* 2010; 365(1554):3065-3081.
39. National Academies of Sciences, Engineering, and Medicine. *Reducing Impacts of Food Loss and Waste: Proceedings of a Workshop* [Internet]. Washington, D.C.: The National Academies Press; 2019. Available from: https://doi.org/10.17226/25396.
40. Food and Agriculture Organization of the United Nations (FAO). *Food wastage footprint-Impacts on natural resources*. Rome: FAO; 2013.
41. Moraes NV, Lermen FH, Echeveste MES. A systematic literature review on food waste/loss prevention and minimization methods. *J Environ Manage* 2021; 286:112268.

Article submitted 30/03/2023
Approved 03/10/2023
Final version submitted 05/10/2023

Chief editors: Maria Cecília de Souza Minayo, Romeu Gomes, Antônio Augusto Moura da Silva