



**EVOLUTION OF RESEARCH RELATED TO FRUIT AND  
VEGETABLE WASTE IN AGRIFOOD SUPPLY CHAINS:  
ANALYSING PAST PUBLICATIONS SEEKING TO IDENTIFY A  
PATH TO FUTURE RESEARCH**

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**ABSTRACT**

Population growth, coupled with a growing demand for food, and its consequent waste and economic, social, environmental, and nutritional impacts, has drawn attention to global discussions related to such issues. In this context, the objective of this research was to provide an overview of studies addressing food waste, in particular, fruits and vegetables. To achieve this purpose, a systematic literature review was carried out, covering papers published in international journals from 2007 to 2017, available in the Science Direct database. The results point out the best practices to avoid food waste, as mentioned in the literature considered. In addition, this study gathered information regarding the main characteristics of publications, such as the evolution of the number of publications per year; main methods and techniques used in research, and which journals excel at covering the theme. This paper may be useful to researchers and practitioners interested in this topic since it systematizes the knowledge related to food waste in fruit and vegetable supply chains.

**Keywords:** agrifood supply chain; best practices; food waste; fruit; vegetable; reduction of food waste.



## 1. INTRODUCTION

As the population grows and urbanizes, the demand for food supplies in large cities also grows. Although the future projection of agribusiness is quite positive regarding production improvements, the problem of agricultural product supply for the next decades is quite serious. Whether, for example, in Africa or India, every year, millions of people suffer from malnutrition and under-nourishment or die of starvation. In many parts of the globe, food production is damaged beyond recuperation (Smill, 2001).

Moreover, population growth continues at greater rates than ever before. Factors, such as the recent rise in agricultural prices on world markets; the slow growth in production when compared to the rapid growth in demand; the emergence of biofuels as an important source of energy; scenarios of global climate change, and the growing scarcity of primary factors for agricultural expansion, (Trostle, 2010; Ajanovic, 2011; Hertel, 2011) contribute to this bleak scenario. With specific regard to grains, in the cases of rice and wheat, export restrictions, demand surges, and, in some situations, droughts, explain dramatic price increases. Concerning maize and soybeans, trade shocks explain the prices rises (Headey, 2011).

According to the FAO – the Food and Agriculture Organization of the United Nations (2018), in 2017, almost 124 million people across 51 countries and territories faced crisis levels of food insecurity and requested humanitarian aid. The report also indicated that conflict and climate disasters have often occurred simultaneously. This fact has also caused significant population displacement. In addition, a solution to the maintenance of food supply would be more related to an increase in agricultural productivity than to an expansion of land use for cultivation and pasture, thus relieving the intense pressure to use resources and preserving the environment (Strassburg et al., 2014).

However, to meet this growing demand, it is not enough to increase land productivity. Food loss and waste must be reduced throughout the food supply chain. In developed countries, the majority of food waste occurs at the consumer/retail end of the supply chain, while in developing countries, such waste occurs at the production, storage and transport stages (Bloem & de Pee, 2017; Ulm et al., 2018). This concern is not new, but it has become increasingly challenging for the world, since it directly affects all the pillars of planetary sustainability: social, economic, and environmental. Besides this, it is estimated that, globally, 30 - 40% of food is wasted, usually fruits, vegetables, and meat, which are very nutritious, but also perishable (Bloem & de Pee, 2017).

In this scenario, the vast majority of countries are more aware of the issue of food waste, thus, there has been growth in the last few years of international interest in measuring the amount of food wasted worldwide (Katajajuuri et al., 2014). The European Commission is developing several initiatives aimed at meeting the Sustainable Development Goal 12.3, the target being to halve per capita food waste at the retail and consumer level by 2030, reducing food loss and waste in supply chains (E.U. Commission, 2019). In this context, several studies have been published in the last few years regarding this matter.

Some of these studies may be highlighted: Buzby, Hyman (2012), Katajajuuri et al. (2014), Byker et al. (2014), and Garrone et al. (2014) approached the measurement of food waste from the point of view of wasted quantities and corresponding monetary value. Visschers et al. (2016), Stancu et al. (2016); Secondi et al. (2015), Graham-Rowe et al. (2014), Quested et al. (2013) studied consumer behavior related to food waste. Williams et al. (2012) dealt with issues related to food waste, packaging types and processes. Scholz et al. (2015) and Parizeau et al. (2015) studied the environmental impact related to food waste. Aschemann-Witzel et al. (2017), Papargyropoulou et al. (2014), Stefan et al. (2013) identified and proposed initiatives to reduce food loss and waste.

Gollnhofer's research (2017) also has implications for issues related to ecological concerns and food waste. The author stated, from the marketing perspective, that fostering normalisation processes could contribute to a more efficient use of resources and help to overcome mental and social barriers that hinder individuals from engaging in responsible behaviour. Bourlakis et al. (2014) developed a framework with sustainability performance indicators in the agri-food supply chains of dairy products, highlighting the problems related to poor product conservation, low-quality product packaging, and limited use of traceability. The study by Parfitt, Barthel and Macnaughton (2010) presented results from a review of food waste issues, combining information on food waste from the international literature and interviews with supply chain experts.

However, it is necessary to pay more attention to the identification of the factors that lead to food loss and waste, and, consequently, lead to an indication of the best practices in food supply chain management. Aiming to identify the factors that generate food loss and waste, it is necessary for research to have a greater focus on all members in the food supply chain (Halloran et al., 2014). Therefore, there is a lack of studies about the food supply chain, especially those of fruits and vegetables, since there is a lack of knowledge about the best practices that contribute to the avoidance of food loss and waste.

Considering the above-mentioned factors, the objective of this study provides an overview of studies addressing food waste, related, in particular, to fruits and vegetables. In order to fulfil this aim, a systematic literature review was carried out, following the protocol of Pagani, Kovaleski and Resende (2015), covering papers published in international journals from 2007 to 2017, with the Journal Citation Reports – JCR© impact factor.

Thus, it was possible to identify the main causes of food waste, and the best practices to avoid food waste pointed out in the selected literature. In addition, this study gathers information regarding the main characteristics of publications, such as: evolution of the number publications per year; main methods and techniques used in research, and which journals excel in their coverage of this theme. This paper may prove to be very useful to researchers and practitioners interested in this topic since it systematizes the knowledge related to food waste in fruit and vegetable supply chains.

The article is organized into the following sections: This first contextualizes the theme and shows its relevance. Section 2 outlines the main concepts related to food supply chain management, and those related to understanding food loss and food waste. Section 3 presents the methodological procedures, describing the steps in the systematic literature review. Section 4 covers the results and discussions, and, finally, Section 5 presents the concluding remarks, limitations of this study, plus potential contributions, and suggestions for future research.

## **2. THEORETICAL BACKGROUND**

### **2.1. Agrifood supply chains**

An agri-food supply chain refers to a set of relations among different segments that establish successive changes in the transformation of food inputs into value for the final consumer.

Everything begins with suppliers of raw materials that will be used in the production process of fruits and vegetables (seeds, seedlings, fertilizers, correctives, pesticides, irrigation, greenhouses, tractors, implements, fuel, personal protective equipment, tools and utensils, and electricity). The farmers undertake the fruit and vegetable production process. After the harvest, value is added to some fruits and vegetables on the farms or in large or artisanal agro-industries: weighing, pre-washing, selection, cooling, and packaging. Next, some fruits and vegetables are sold “in natura” to industries and other distribution channels until they reach the final consumer, whether through wholesale, retail, or imports/exports.

However, there is a series of wastage throughout all the stages in the agrifood supply chain, from the countryside to the home of the final consumer (Betz et al., 2015; Stancu, Haugaard & Lähteenmäki, 2016). In the context of the relations among the members of the agrifood supply chain, the influence of some on others in decision-making processes causes food loss or waste in a constant cycle (Halloran et al., 2014).

In the agrifood supply chain, an enormous amount of food is lost, even in the field in the primary production sector, in which food producers, ranging from family farms to large producers, lose a measurable amount of food fit for consumption, often due to the preferences of the other members of the chain (Halloran et al., 2014).

Then, the production and transformation stages present the possibility of minimizing waste by processing the fruits and vegetables that can be treated in this way. At the supply chain links responsible for food marketing, about 45,676 tons of food are wasted each year (Scholz, Eriksson & Strid, 2015). Globally, it is estimated that 30 - 40% of the food produced is wasted, mainly perishable fruits and vegetables and meat (Bloem & de Pee, 2017). However, according to Parfitt, Barthel and Macnaughton (2010), there are information gaps and uncertainties, and no consensus on the proportion of global food production that is currently lost. Since 2010, the estimate has ranged from 10 to 40% of world output.

In the case of developing countries, structural, planning, and logistical bottlenecks limit improvements in the stages of the fruit and vegetable supply chains. Better coordination and information-sharing from the production units to the point of sale, as well as improvements in production technologies and logistical processes, would contribute to waste reduction (Halloran et al., 2014). Therefore, it is possible to realize that integration of the agricultural supply chain is indicated as a solution for the best use of food, and, consequently, for a reduction in food loss and waste (Halloran et al., 2014).

On the other hand, it is in households in developed countries that the greatest amount of food suitable for consumption is wasted (Quested et al., 2013; Visschers et al., 2016). According to Williams et al. (2012), it is the waste generated by the final consumers that has a more significant impact than the waste created in the distribution chain. Indeed, the post-harvest stage presents the greatest challenge to reducing food waste, that is, making it possible in the future to ensure a consistent, sustainable supply of food for the world's entire population (Buzby & Hyman, 2012).

## **2.2. FOOD LOSS VERSUS FOOD WASTE**



There is no worldwide consensus on the definitions of food loss and food waste (Buzby & Hyman, 2012). Food loss or waste are related to all foods that are effectively lost and wasted, regardless of the stage in the supply chain, for economic reasons, by the date of expiration, but which might still be fit for human consumption (Halloran et al., 2014).

Papargyropoulou et al. (2014) adopted the definition that food waste is associated with any food that has been diverted from the function of human food. Visschers et al. (2016) referred to food waste ranging from household waste to those used in composting or animal feed. Buzby & Hyman (2012) stated that food loss can be related to physical and nutritional attributes and may be present in the first production stages on the farms. On the other hand, waste food could be related to the foods that can be consumed, but are, in fact, thrown away.

Halloran et al. (2014), Quested et al. (2013) and Stancu et al. (2016) agreed that, in developed countries, the largest share of consumable food is wasted. Thus, the European Union members have set targets in order to minimize food waste (Scholz, Eriksson & Strid, 2015).

There is great difficulty in accurately measuring the amount of food that is wasted. This is due to lack of standardization of the methods and techniques used for quantification (Stancu, Haugaard & Lähteenmäki, 2016). In addition, the regulations that standardize and regulate the commercialization of foods establish standards of size, color, form, among others, which can in many cases exclude food in good condition for consumption, but does not meet the standardization requirements, and so ends up being wasted (Halloran et al., 2014).

In developed countries, most of the losses occur at the two ends of the supply chain, whereas, in developing nations, losses are most acute in agriculture and food distribution (Fao, 2011). There are large losses of fruits and vegetables at all stages of their production processes, especially in bulk transport (Fao, 2011). In addition, Parfitt, Barthel and Macnaughton (2010) highlighted that there is a demand for quantitative evidence of food waste covering agri-food supply chains in developing countries and the rapidly evolving BRICs.

It should be noted that a considerable part of the waste is associated with a lack of adequate structure in the logistics processes involved, since the way the supply chain components are structured directly influences product quality (Halloran et al., 2014).

Amidst the visible power of chain management by some key members, the Fao (2013b) reports examples of cases of waste due to overproduction. What happens is the lack of commitment and the communication failures between the distribution links and production links, through the non-fulfilment of orders from retailers. According to this report, in addition

to not complying with the purchase of all previously ordered foods, supermarkets often prohibit their unsold products from being donated, because they associate their brand with a lack of credibility (Fao, 2013b). In summary, the main indicator of high wastage in high-income countries is consumer behavior. However, Furthermore, as well as losses in developing countries are caused by a lack of coordination among different actors in the supply chain from the time before production to final distribution (Fao, 2011).

The perishability of several products takes a variety of forms, leading to greater waste in establishments that do not carry out broad control considering the specificity of each item in their stocks. Food waste in developed countries is proportional to the large-scale product supply (Belik et al., 2012).

### **3. METHODOLOGICAL PROCEDURES**

This research is characterized from the point of view of its objectives as descriptive; from the viewpoint of the approach to the problem, it is qualitative, and, as for the technical procedure, it is a systematic literature review. There are two types of literature review: the narrative (traditional) literature review that does not make explicit the search and selection criteria of the papers; and the systematic review, which follows a protocol with well-defined stages, making explicit the search criteria, selection and elimination of articles, in order to guarantee replicability (Cronin, Ryan & Coughlan, 2008).

The systematic literature review process guarantees greater rigor, robustness and replicability for the research (Denyer & Tranfield, 2009). In addition, Webster and Watson (2002) stated that literature reviews present two perspectives: (i) revision of topics that have accumulated knowledge and require analysis and synthesis; and (ii) revision of emerging issues, whose contribution is the exposure of potential theoretical foundations, which is usually not as extensive as the former. The perspective adopted in this article fits the second notion of literature review.

With the intention of demonstrating the state of the art on the subject of food loss and waste, the literature review was carried out with a systematic perspective, whose approach is structured in a protocol of selection and analysis of the references, involving the steps proposed by Pagani, Kovaleski and Resende (2015).

First, the research problem was defined: Waste in the food supply chain. Next, the keyword that would be used in the search was defined: Food Waste. In the sequence, the definition of Science Direct as the source of papers was made. Science Direct was chosen, as

it has a wide variety of articles with a high impact factor, spanning several knowledge fields. The analysis period was from January 2007 to December 2017. It was found that 437 papers were published in this period. The articles were analyzed by reading the titles and abstracts. Thus, from the 437 articles, 79 articles remained.

There are several systematic literature review protocols (Cronin, Ryan & Coughlan, 2008; Denyer & Tranfield, 2009; Liberati et al., 2009; Higgins & Green, 2011; Pagani, Kovaleski & Resende, 2015). It was opted to use the Methodi Ordinatio protocol, which is based on a multi-criteria decision aid approach, proposed by Pagani, Kovaleski and Resende (2015). To classify the quality of the articles, the calculation of the InOrdinatio index was obtained by the following formula:

$$(IF / 1000) + \alpha * [10 - (\text{Year Search} - \text{Year Published})] + (\Sigma Ci) \quad (1)$$

This formula allows the best articles to be selected by sorting the highest scores. The calculation considers the year of publication, the impact factor of the journal in which it was published, and the number of quotations. The authors, Pagani, Kovaleski and Resende (2015) advised the researcher to determine the cut line so that only articles above the line would be read in their entirety. In this way, 17 articles were selected on the basis that they presented an InOrdinatio index over 123 (see Figure 1 below): At step 1, “Starts”, the author should choose the option “Articles”, as the journal section to submit his paper. While in this step, the author should verify the submission checklist and also agree with the copyright terms for submission.

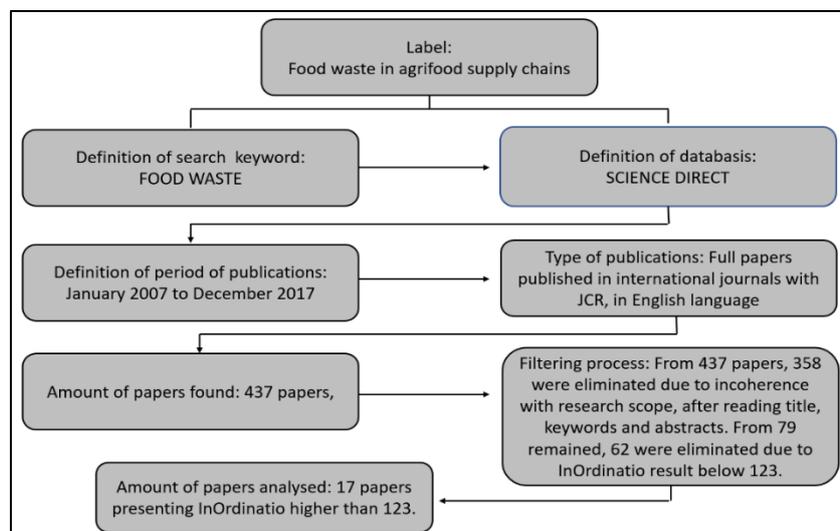


Figure 1: Steps of the Systematic Literature Review

After definition of the inclusion and exclusion criteria, two filtering processes were carried out. The first by reading the titles, keywords and abstracts, and the second by calculation

of the InOrdinatio index. Finally, the 17 remaining papers were analyzed by the Content Analysis proposed by Bardin (1977), in order to gather the main characteristics of papers, and to obtain the main causes of food waste and the best practices to reduce or avoid such waste in agrifood supply chains. Following the steps proposed by Bardin (1977), the data papers were analyzed based on the definition of categories, which aimed to capture patterns repeated in most of the collected data. The categories were created *a posteriori*, that is, they were created according to the situations identified in the data collected and occurred repeatedly.

#### 4. RESULTS AND DISCUSSION

In the midst of this scenario, the vast majority of countries are more aware of the issue of food waste. In this sense, there has been a growth in recent years of international research in measuring the amount of food wasted worldwide. Table 1 shows the direction of this international research:

Table 1: Research direction

Authors (year)	Research direction
(Buzby; Hyman, 2012); (Katajajuuri et al., 2014); (Byker et al., 2014); (Garrone et al., 2014)	Measure waste from the point of view of wasted quantities and or their monetary correspondence
(Stancu et al., 2016); (Graham-Rowe et al., 2014); (Quested et al., 2013); (Secondi et al., 2015); (Visschers et al., 2016)	Consumer Behaviour
(Williams et al., 2012)	Packaging
(Scholz et al., 2015); (Parizeau, et al., 2015)	Environmental Impact
(Stefan et al., 2013); (Aschemann-Witzel et al., 2017); (Papargyropoulou et al., 2014)	Proposed initiatives and outputs to reduce loss and waste

According to Table 1 about the direction of the international research, most of the papers found had studied the behavior of the final consumer related to food waste, followed by studies measuring the quantities wasted, and the environmental and monetary impacts generated.

Regarding the evolution of the international publications, Figure 2 shows the absence of studies in the years 2007 to 2010, due to the fact that they were eliminated by the Methodic Ordination selection formula, which can be considered a limitation to this research.

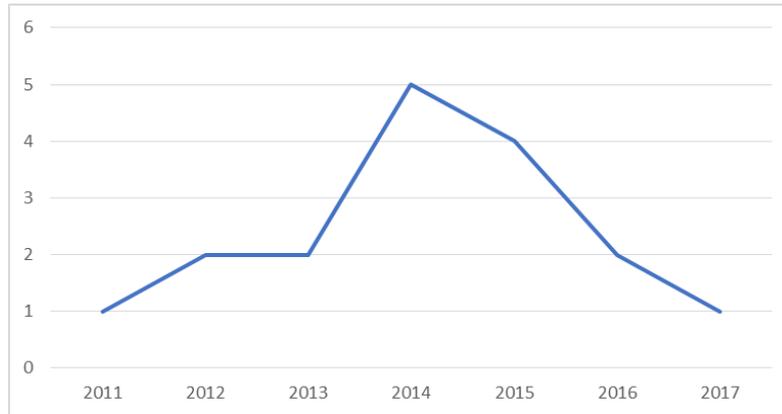


Figure 2: Evolution of the number of publications per year

Regarding the year 2017, the lower number of publications can be explained by the fact that some journals published the December edition on the first day of the month. This research was conducted during the first fifteen days of December 2017. Table 2 presents the methodological design of the papers analyzed.

Table 2: Methodological Design

Author (Year)	Research Technique	Data Collection Instrument	Methodological Approach	Data Analysis Technique
Stancu et al. (2016)	Survey	Questionnaire	Quantitative	Descriptive Statistics
Scholz et al. (2015)	Case Study	Documents	Quantitative	Descriptive Statistics
Stefan et al. (2013)	Survey	Questionnaire	Quantitative	Descriptive Statistics
Quested et al. (2013)	Case Study	Documents	Qualitative	Content Analysis
Papargyropoulou et al. (2014)	Case Study	Interview	Qualitative	Content Analysis
Visschers et al. (2016)	Survey	Questionnaire	Quantitative	Descriptive Statistics
Garrone et al. (2014)	Case Study	Interview	Qualitative	Content Analysis
Williams et al. (2012)	Case Study	Interview	Qualitative	Content Analysis
Graham-Rowe et al. (2014)	Case Study	Interview	Qualitative	Content Analysis
Parizeau et al. (2015)	Case Study	Questionnaire	Quantitative	Descriptive Statistics
Aschemann-Witzel et al. (2017)	Multiple Case Study	Interview	Qualitative	Content Analysis
Secondi et al. (2015)	Survey	Interview	Qualitative	Descriptive Statistics
Betz et al. (2015)	Case Study	Questionnaire	Quantitative	Descriptive Statistics
Byker et al. (2014)	Survey	Questionnaire	Quantitative	Descriptive Statistics
Sonnino; McWilliam (2011)	Case Study	Interview	Quali/Quantitative	Descriptive Statistics

Katajajuuri et al. (2014)	Survey	Questionnaire	Quantitative	Descriptive Statistics
Buzby; Hyman (2012)	Documental research	Documens	Quantitative	Descriptive Statistics

The context presented is based on the Research Techniques, the Data Collection Instrument, the Methodological Approach, and Data Analysis Techniques of the publications. Among the research techniques, the studies analyzed present great variety. The case study was the main design. Regarding the instrument, the interview was highlighted as the instrument most used for data collection.

It has also been found that most of the works come from Denmark (3) and the United Kingdom (3), followed by the United States (2), Italy (2), Sweden (2), Germany (1), Switzerland (1), Malaysia (1), Finland (1), and Canada (1). Regarding publication, Figure 3 shows the distribution of the papers analyzed among the main journals: Malaysia (1), Finland (1), and Canada (1). Figure 3 shows the distribution of the papers analyzed among the main journals:

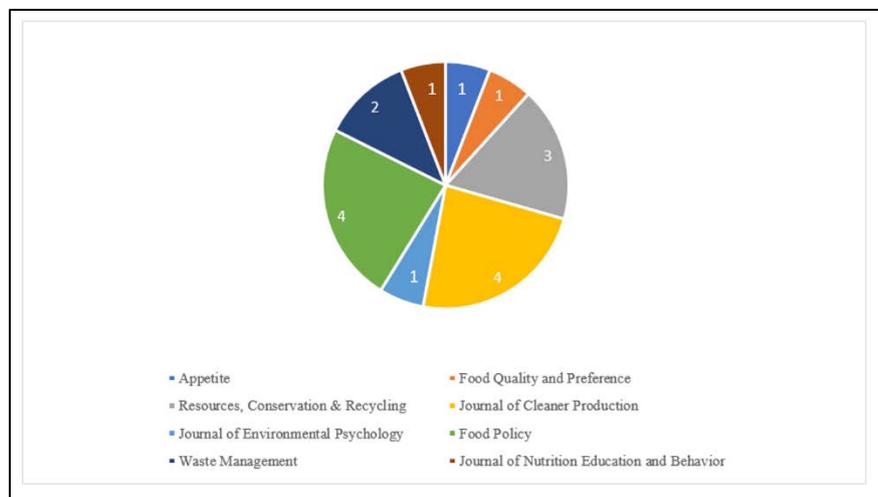


Figure 3: Main Journals for Publication

Studies on food loss and waste have different approaches. While, on the one hand, they aim to identify the factors that lead to domestic food waste; on the other, some studies aim to measure the impacts of food waste. The following categories, based on the Bardin (1977) content analysis technique, were created to classify the different approaches found: Behavioral and Cultural Generation factors; Economic Impact; Environmental Impact.

The great majority of studies aim to understand the behavior of the final consumer, listing the factors that drive food waste, considering that some studies point out that, at the consumption stage, there is more generation of food waste, and a greater possibility of

prevention (Stancu, Haugaard & Lähteenmäki, 2016). However, although consumers appear to make the greatest contribution to the volume of wasted food, there is almost no information on the drivers of such behavior in consumer households (Stefan et al., 2013). In this sense, the minimization of food residues in developed countries should be focused on the retail and consumption stages (Papargyropoulou et al., 2014). The waste of consumer-related food is a complex issue that requires collaboration among various actors in the supply chain, along with actions to increase awareness (Aschemann-Witzel et al., 2017).

Based on the results, it is possible to state that poor management of the routines related to the planning, purchase and reuse of food leftovers are the main factors that lead to food waste generation (Stancu, Haugaard & Lähteenmäki, 2016). This idea is corroborated by the Stefan et al. (2013) study, in which the authors identified the management of consumer planning and purchasing routines as a way of predicting food waste.

With respect to food waste in households, consumers do not have much understanding of the amount of waste and the economic value of what they are wasting (Quested et al., 2013). Similar results were found in the Visschers, Wickli and Siegrist (2016) study, in which it was verified that the issues of a monetary nature have little impact on the amount of food thrown away. In this sense, raising consumer awareness about the financial costs of food waste, especially fruits and vegetables, may have the impact of generating less waste of this type of food of lower added value (Visschers, Wickli & Siegrist, 2016).

At the consumer level, people's behaviour in relation to food waste was analysed in Secondi, Principato and Laureti (2015). As a result, the authors found some patterns: First, there are groups of countries characterised by similar patterns of behaviour. Second, people living in large cities tend to produce more waste. Third, public-private partnerships and community-based interventions to deal with food waste are encouraged (Secondi, Principato & Laureti, 2015).

Summarizing, the results demonstrate that wasted fruits and vegetables are more related to problems, such as excessive and incorrect handling by consumers and retailers, lack of facilities and structure for better storage, and, at the commercialization stage, poor management of purchasing processes due to lack of management tools and control of demand and inventory.

Among the articles analyzed, we highlight the identification of initiatives in the food supply chain aimed at reducing waste by the final consumer (Aschemann-Witzel et al., 2017). According to these authors, there are three types of initiatives: information and training;

redistribution/retail; and supply chain changes. The results show that collaboration among stakeholders, the timing and sequence of initiatives, the competencies on which the initiatives are based, and large-scale operations are key success factors.

In this context, some initiatives conducted worldwide are highlighted in Table 3.

Table 3: Worldwide Initiatives to Reduce Food Waste

Initiative	Scope	Organisation	Description
Proper solutions for food packaging in developing countries	Developing countries	FAO	Identify solutions and technologies of packaging in developing countries, contributing to the prevention and reduction of global food waste in the stages of production, post-harvest, distribution, processing and at the point of sale.
Global food loss and waste	Worldwide	FAO	Identify the causes of food loss and waste, and provide guidelines of prevention and reduction of waste, besides examples of best practices for different stakeholders.
Wise-Up on Food Waste	Worldwide	Unilever Association of Sustainable Food Solutions	Creation of an auditing tool for food waste and reduction of waste, with tips aimed at suppliers and chefs in order to monitor food waste, and at consumers in order to reduce household food waste.
	East African countries	USA agency for international development and multi-stakeholders	Offer technical support and capacitation projects to improve the performance of food companies when accessing the international market, meeting quality and safety standards. Provide tips to help families reduce food waste.
Stop food waste	European Union	European Commission	Provide tips to help families reduce food waste.
Guidelines to devise programs to prevent food waste	European Union	European Commission	Provide guidelines for public policy-makers to develop better food waste prevention programmes. Assist food companies, environmental agencies and organisations. It has a sectoral approach in order to reach the main food waste producers, aiming at improving food waste prevention techniques.
EU Platform on Food Loss and Food Waste	European Union	European Commission	Through the EU Platform on Food Loss and Food Waste, the Commission is analysing in close co-operation with industry, consumer and NGOs, research institutes and the EU countries' policy experts, how to reduce food waste without compromising food safety, while also discussing options for possible EU actions

Source: Devised by the authors, adapted from the European Commission; Unilever, FAO & USA Agency (2019).

In Table 4 it is possible to perceive the worldwide commitment to achieving the purpose of reducing food waste at the production, distribution, retail and consumer levels.

The study by Visschers, Wickli and Siegrist (2016), studied which factors driving waste are related to the quantities of waste generated by the families surveyed. It is perceived that purchases in quantities beyond what is necessary, fear of taking advantage and lack of

knowledge about the storage of products, stand out as the main causes of the increase in food waste generation.

A similar study was carried out by Graham-Rowe et al. (2014), in which the authors identified 4 categories that drive food waste: (1) Being a good provider in the home; (2) Prevent inconveniences related to lack of food; (3) Do not consider waste reduction as a priority; and (4) Disclaimer. Regarding the measurement of food waste and the driving factors, it was verified that lack of awareness, lifestyle, buying practices and beliefs, are related to food waste generation (Parizeau, von Massow & Martin, 2015).

There are also studies focusing on the economic impact of food loss and waste, such as the study by Buzby and Hyman (2012), which aimed to estimate the monetary value of food waste for retailers and final consumers. According to the study, fruits (9%) and vegetables (17%) contributed to the total food loss (US\$ 165.579 million) in the United States in 2008.

Other studies, also measuring the effects of waste, aim to analyse the environmental impact of food waste, verifying the levels of carbon emissions from supermarket waste, and analyzing all the steps. The fruit and vegetable sector reached a wasted mass of 85%, and 46% of the carbon levels (Scholz, Eriksson & Strid, 2015).

Also regarding the environmental approach to the studies, Papargyropoulou et al. (2014) proposed that production becomes more sustainable, aiming not only to avoid excess supply, but also to contain the growing demand, a smaller quantity of waste being more feasible to deal with. The second option would be to redistribute excess food to people with little access. In this case, (Papargyropoulou et al., 2014). The European Commission has initiatives related to measures to clarify EU legislation related to waste, food and feed, as well as facilitate food donation and use of food no longer intended for human consumption as animal feed (EU Commission, 2019).

Other studies are related to the creation of a model for the proposition of strategies to minimize this waste, in which the authors devised a method that quantifies the surplus food so that it is not wasted. Among the causes of production surpluses, food products that fail to comply with market standards predominate (Garrone, Melacini & Perego, 2014),

In addition, a study focusing on how packaging influences the amount of waste generated was also found (Williams et al., 2012). The author states that about 20% of household food waste may be related to packaging. Participants reported the existence of very large food packages. Regarding fruits and vegetables, the respondents did not relate the waste to a lack of

packaging. However, due to poor storage, about half a kg of food (fruits, vegetables and dairy products) was wasted per household each week.

In sectors such as hospitals and schools, sustainable measures need to be implemented in the food services sector to reduce food waste and improve efficiency (Betz et al., 2015). The study results corroborate the findings of Sonnino and McWilliam (2011), in which there was a correlation between the general quality of the hospital meal service and the large amount of wasted food. Regarding schools, the largest amount of food waste involved vegetables. Fruit had the lowest level of residues (33%). For vegetables, on a daily basis, the level ranged between 26.1% and 80.1%. Vegetables represented the largest quantity of waste (51.4%) (Byker et al., 2014).

Finally, Katajajuuri et al. (2014) determined the volume of avoidable food waste and its distribution among the members/links (producers, distributors, retailers, consumers) in the Finnish food supply chain. Although the research was directed toward the final consumer, the food services sector, the industry, and the retail sector were also verified. It is worth noting that the largest concentration of food waste, such as fruits, vegetables and bread, is generated in retail.

Table 4 gives an overview of the practices pointed out in the international literature considered for this systematic literature review, aiming to reduce waste.

Table 4: Best practices found in international literature

Best practices found in literature	Author (Year)
Appropriate food handling	Buzby & Hyman (2012)
Proper packaging	Garrone, Melacini & Perego (2014), Halloran et al. (2014)
Improvement in marketing structure and facilities	Quested & Parry (2013), Scholz Eriksson & Strid (2015)
Demand forecast (pull demand) and inventory control	Buzby & Hyman (2012), Papargyropoulou (2014), Stefan et al. (2013), Garrone, Melacini & Perego (2014), Betz et al. (2015), Sonnino & McWilliam (2011)
Supply chain management (supply, collaborative relationships, partnerships, information sharing).	Buzby & Hyman (2012), Papargyropoulou (2014), Stefan et al. (2013), Garrone, Melacini & Perego (2014), Betz et al. (2015), Sonnino & McWilliam (2011); Aschemann-Witzel et al. (2017)
Education and consumer awareness (campaigns about handling)	Aschemann-Witzel et al. (2017), Byker et al. (2014), Graham-Rowe & Sparks (2014), Stefan et al. (2013), Stancu, Haugaard & Lahteenmaki (2016), Secondi, Principato & Laureti (2015), Parizeau, Massow & Martin (2015), Visschers, Wickli & Siegrist (2016)
Waste management (recycling, reuse)	Quested et al. (2013), Visschers, Wickli & Siegrist (2016), Papargyropoulou et al. (2014)

Table 4 presents the main steps to be taken to reduce food waste. Special attention is due to the practices related to education and awareness of the final consumer, combined with the greater integration and collaboration of the members of the agrifood supply chain, covering farmers/producers, distributors, and retailers.

## 5. CONCLUDING REMARKS

The objective of this paper was to provide an overview of the international literature on food waste, specifically related to fruits and vegetables, which are very perishable and represent the greatest amount of loss in agrifood supply chains. This aim was achieved through the identification of the main causes of food waste. Furthermore, the best practices were presented to avoid it. In addition, this study gathered information regarding the main characteristics of relevant publications, such as: evolution of publications per year; main methods and techniques used in research, and which journals excel at covering the theme.

The results demonstrate that the food waste regarding fruits and vegetables is more related to problems, such as excessive and incorrect handling by consumers and retailers, lack of facilities and structure for better storage, and, at the commercialization stage, poor management of purchasing processes due to lack of management tools and control of demand and inventory.

As limitations of the study, one may point out the protocol used for this systematic literature review (Methodic Ordination), as well as the criteria chosen as parameters to include and exclude publications. Other existing protocols and criteria can lead to different results. Besides these, the first filtering process, which covers reading the titles, keywords, and the abstracts to verify conformity with the scope of the research, is related to the subjectivity of the researcher.

As a suggestion for future research, studies could approach the entire agrifood supply chain in an integrated way, covering farmers/producers, distributors, retailers and consumers, as well as public policymakers and other organizations. Moreover, studies focusing on the drivers of food waste related to consumers in developed countries, comparing them with those of consumers from developing countries, constitute an interesting path to future research. Studies focusing on the comparison of impact in quantities of food waste related to food with and without packaged. Future research could focus on alternatives and initiatives of food donation, as well as the reuse of food in circular systems. Finally, studies aiming to measure

the awareness of consumers related to food waste in developing and developed countries could be conducted.

We can also highlight the studies analyzing the final consumers' discarding behavior, especially related to the predictors of consumption and consequent disposal, as well as the deepening of cultural values and lifestyles, with the aim of creating solutions and campaigns that directly impact the end of the agrifood supply chain, which is the consumer. Studies measuring the percentages of waste generated, as well as the respective monetary values and environmental impact, may be further explored.

The contribution of this study lies in the systematization of knowledge on food waste from 2007 to 2017, which has reinforced the importance of studies about members of the post-harvest chain, especially in relation to distributors, retail, wholesale, restaurants and other food services, and especially the final consumer. With regard to the latter, this study highlights the need to carry out campaigns and involve public-private partnerships with the intention of educating and raising awareness about the economic, environmental and social impacts related to such waste, which can involve both public and private managers. Considering the novelty of this topic, studies addressing this issue with a qualitative approach could contribute to future research in this area.

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