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DOCTORAL THESIS ABSTRACT

Research on food waste management in the context of the circular economy

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Chapter 1. Theoretical considerations regarding food loss and waste management: causes and consequences

In the current global context, characterized by population growth, climate change, and the depletion of natural resources, the issue of food loss and waste is becoming increasingly acute. These phenomena not only pose a major challenge to food security but also represent a significant source of negative environmental impact, contributing to greenhouse gas emissions and the depletion of natural resources. The Food and Agriculture Organization of the United Nations (FAO) estimates that approximately one-third of the food produced globally is lost or wasted along the food supply chain, which results in a huge waste of resources such as water, energy, and labor. The circular economy offers a sustainable alternative to the traditional linear economic model, focusing on minimizing waste and reusing resources. In this context, addressing food loss and food waste becomes essential for creating more efficient and resilient food systems. The transition to a circular economic model not only reduces the ecological impact of food production and consumption but also contributes to improving global food security and increasing economic efficiency.

The terminology related to food loss and food waste can sometimes be confusing. Although these phenomena can occur at any point along the food supply chain, there is a subtle difference between the two concepts. Food losses refer to food products that are fit for consumption but never enter the food supply chain, being wasted already at the primary production stage. These losses are mainly caused by inefficiencies in the food supply chain, such as unfavorable weather conditions, inadequate storage, improper handling, as well as poor infrastructure and logistics. Food losses are predominantly found in non-industrialized and low-income regions, where infrastructure and logistics are insufficient. In industrialized regions (such as North America, Europe, and industrialized Asia), where incomes are higher and infrastructure is more modern, food waste primarily occurs in the distribution (marketing) and consumption (households, HoReCa) stages.

Food waste refers to food that is still fit for consumption but is not consumed for various reasons, usually related to consumption habits and patterns. There is a significant difference between the concept of food loss and that of industrial losses. Food losses are unintentional, while industrial losses, which are an integral part of the industrial production process, are considered normal and are planned and quantified within production plans. Industrial losses include industrial waste (such as intestinal content resulting from slaughter) and residues from various technological operations (such as cutting, processing, shaping, drying, packaging, etc.). Although the concepts of food waste and food waste materials are

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often used interchangeably, there is an essential difference between them: food waste refers to losses of food that are still fit for consumption, while food waste materials represent food that is no longer edible, has already been discarded, and can no longer be consumed. Given the economic, ecological (such as the depletion of natural resources and environmental pollution), and social consequences (such as reduced access to and availability of food), food losses and food waste are recognized as major contributors to food insecurity and to the reduction of the sustainability of food systems.

The food supply chain, also known as the agri-food chain, represents a succession of stages in the production and distribution of food (such as fruits, vegetables, dairy products, eggs, meat, fish, seafood, etc.) intended for human consumption. This chain extends from the farm to the final consumer, through retail systems or public or private food services. Within the food supply chain, there are a series of stages (phases or points), each involving different agricultural and/or industrial technological operations. In rural communities, the food supply chain may be short (farm – local market – final consumption). On the other hand, in urban areas, the food supply chain is longer and more complex, including the following key points:

- ✧ (1) primary agricultural production (harvesting, post-harvesting, on-farm processing)
- ✧ (2) industrial processing (e.g., refrigeration, freezing, drying, washing, chopping)
- ✧ (3) storage (food storage warehouse)
- ✧ (4) distribution (retail)
- ✧ (5) final consumption: in households, in private food services (HoReCa), in public food services (Figure 1).

Figure 1. Key points in the food supply chain: (1) farm and agricultural processing unit; (2) industrial processing unit; (3) storage facility for finished food products; (4) distribution (marketing) – retail/private food service (HoReCa), (a) storage facility, (b) kitchen; (5) final consumption in households/final consumption in restaurants
Source: own creation

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Figure 1 illustrates the interconnected stages of the food supply chain, through which agri-food products are transported from the farm (1) to the final consumer (5). Stage (1) includes activities closely related to the cultivation, harvesting, and primary agricultural production. This stage has a direct impact on the efficiency of the food system in generating agricultural biomass and using it to meet human nutritional needs. The next stage (2) involves industrial processing, which is the transformation of raw materials of plant and animal origin into food products with consistent quality, intended for human consumption. The following two stages (3 and 4) focus on market and distribution processes (wholesale and retail). The final stage (5) coincides with end consumption, which occurs either within households or outside, through private food services (HoReCa) or public food services (such as hospitals, school cafeterias, prisons, etc.). At every stage of the food supply chain, from primary production (farm) to final consumption (fork), food losses and food waste can occur.

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Chapter 2. Analysis of causes generating food waste and strategies for managing food waste in the HoReCa sector

In the current context of global challenges related to sustainability and the efficient management of resources, food waste represents one of the most pressing issues faced by the HoReCa sector. Food waste has significant implications not only from an economic perspective but also from ecological and social standpoints, contributing to increased greenhouse gas emissions, considerable financial losses, and the perpetuation of social inequalities through the improper use of food resources. According to specialized literature, the HoReCa sector is responsible for a significant proportion of global food waste, considering the large volume of food handled daily and the complexity of the operational processes involved.

Food waste is a complex and multidimensional problem with significant implications for the environment, economy, and society. In recent years, research on food waste and sustainability in the HoReCa sector has experienced exponential growth, becoming emerging points of interest and reflecting the growing attention of the academic community and decision-makers towards addressing these challenges. Scientific publications on food waste management and sustainability have proliferated in recent years. A bibliometric analysis on this topic not only provides an overview of the current state of research but also highlights areas where progress is needed to improve sustainability in the HoReCa sector in the context of reducing food waste.
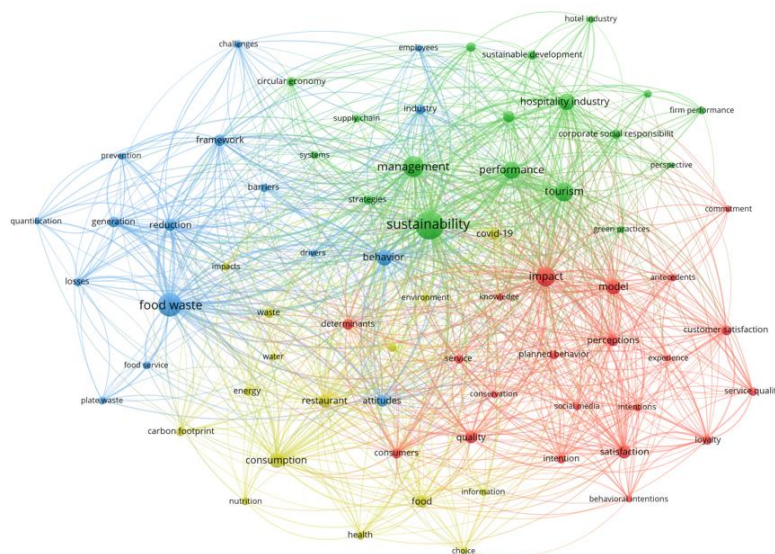

Figure 2. Network visualization in VOSviewer
Source: VOSviewer software report

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Figure 2 highlights the keywords strongly associated with food waste management and sustainability in the HoReCa sector, as well as how they are interconnected within academic works. In the current study, four clusters were distinguished, marked by various colors (red, green, blue, yellow). Each cluster is composed of keywords that are closely related to each other, often indicating a specific subdomain addressing a common theme. The words within each cluster are arranged based on frequency of occurrence, being embedded in a common concept.

The first cluster, highlighted in red, indicates that the success of food waste management initiatives in HoReCa is strongly influenced by consumer perceptions and behaviors, service quality, and the overall impact of these factors on the industry. It emphasizes the importance of customer satisfaction-focused approaches in the development and implementation of food waste reduction strategies in the HoReCa sector. Thus, the most connections with other elements in the network occur for three keywords from the red cluster, which also play an essential role in the thematic structure of the network: *impact*, *satisfaction*, *model*.

The second cluster highlights the need to integrate food waste management into the hospitality industry, embedding this aspect within a broader framework of sustainability and efficient management. By implementing sustainable practices and carefully optimizing resource use, this industry can reduce food waste while also improving its operational performance and, consequently, its financial performance. Moreover, as tourism represents an important economic pillar in the hospitality industry, this segment plays a crucial role in the link between sustainability and food waste management. In this context, tourist destinations, especially those that attract a large number of visitors, bear increased responsibility, offering important perspectives for promoting and implementing green practices. In the green cluster, it is emphasized that most of the connections with other elements in the network are based on a few central keywords in the research theme: *sustainability*, *management*, *tourism*.

The third cluster, the blue one, provides a complex and nuanced picture of the challenges related to the prevention and quantification of food waste. This issue is closely linked to employee behavior, as employees represent an important factor in reducing leftover food. In this regard, it is crucial to adopt effective strategies for employee education and continuous training, as well as to improve communication and awareness at the organizational level to overcome existing obstacles. The blue cluster is strongly oriented towards behavioral analysis related to food waste reduction, as highlighted by the following

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keywords that have numerous connections with other elements in the network: *food waste*, *behavior*, *reduction*.

The last cluster in the bibliometric network, the yellow cluster, reflects a focus on the complex impact that consumption patterns in restaurants have on environmental health-related issues. The COVID-19 pandemic has highlighted the vulnerabilities of the food system, and in response to these challenges, the HoReCa sector has had to reevaluate and reconfigure practices, particularly those related to sustainable resource management, such as conserving water supplies. Alongside reducing the carbon footprint, minimizing food waste represents a key element oriented towards the transition to sustainability. These aspects are supported by the keywords in the yellow cluster, with the most connections across the network: *consumption*, *restaurant*, *food*.

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Chapter 3. Qualitative study on HoReCa managers' perceptions of food waste reduction strategies

In the context of food waste management, qualitative studies provide a deep understanding of how different stakeholders (e.g., restaurant managers) perceive food waste. This helps identify attitudes and beliefs that influence behaviors related to this phenomenon. Moreover, behavioral perspectives, which refer to understanding how individuals' actions, habits, and decision-making processes contribute to food waste, serve as a starting point for exploring the specific challenges faced by HoReCa units in implementing strategies that are more likely to be effective. The adoption of sustainable practices in the HoReCa sector, which can overcome certain barriers, is based on uncovering motivational factors. On one hand, qualitative research can provide deep insights into these motivational factors, and on the other hand, it can reveal important and useful patterns for food waste management in the HoReCa sector.

The challenges associated with food waste management in the HoReCa sector are encountered, particularly by top management in each unit, and are based on procurement practices, portion and menu planning, and reducing food surplus. Additionally, a deeper understanding of effective food waste management strategies to overcome a range of challenges creates a framework for a sustainable food waste reduction plan in this sector, offering multiple advantages for all stakeholders as well as for the environment. Thus, the eight research questions (RQs) of this study are:

- ✧ **RQ1: How is food waste perceived in the HoReCa sector?**
- ✧ **RQ2: What is the current stage of implementation of food waste reduction strategies at the unit level?**
- ✧ **RQ3: What is the perception of food waste reduction strategy implementation at the government level, in the context of aligning with sustainable development goals?**
- ✧ **RQ4: How can portion management be achieved in the context of reducing food waste?**
- ✧ **RQ5: What menu planning innovations could reduce food waste?**
- ✧ **RQ6: How can production and resources be optimized to reduce food waste?**

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⬧ **RQ7: What changes have occurred in the approach to food waste management post-COVID-19?**

⬧ **RQ8: What are the reasons and benefits that influence the decision to reduce food waste?**

The analysis of respondents' answers reveals eight important categories (concepts), considered as "responses" to the RQs, which can be defined as: the general perception of food waste in the HoReCa sector; the current stage of implementation of food waste reduction strategies at the unit level; the perception of food waste reduction strategy implementation at the government level, in the context of aligning with sustainable development goals; portion management; menu planning; production and resource optimization; post-COVID-19 changes in the approach to food waste management; and the reasons and benefits associated with reducing food waste.
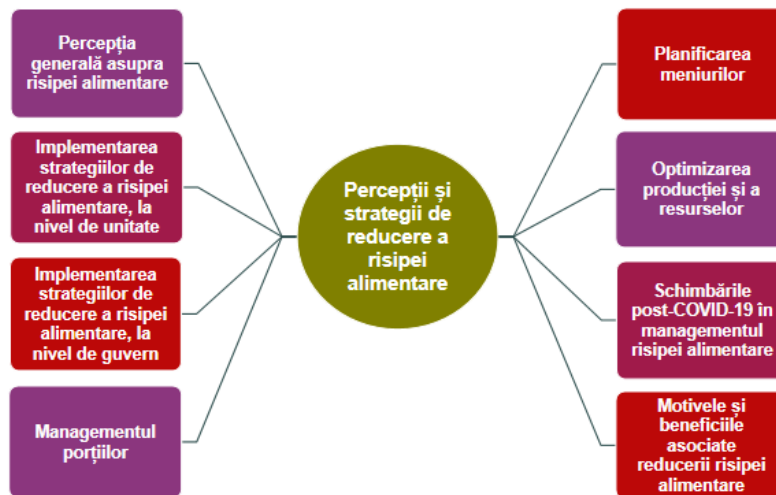

Figure 3. Mind map of the eight concepts defining food waste management in the HoReCa sector
Source: own contribution created in NVivo software

Figure 3 presents all eight concepts that define a series of perceptions and strategies for reducing food waste in the HoReCa sector, grouped within a mind map, which serves as a visual tool for organizing ideas in a structured manner.

The thematic analysis of the *first research question* highlights various critical aspects and perspectives on the challenges related to food waste management in the HoReCa sector. The most dominant theme is the respondents' perception that food waste is a clear and persistent problem. Thus, the primary concern of the respondents is that food waste is not just a temporary or occasional event, but a phenomenon perceived as clear and persistent by both managers and customers, worsening over time if not properly managed.

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The thematic analysis of the *second research question* revealed five important themes. The most significant theme related to the implementation of food waste reduction strategies at the unit level is represented by current efforts towards implementation. Most respondents are actively involved in applying food waste reduction measures. Therefore, in most units, there is a clear commitment to this issue through practices such as the application of the FIFO method; efforts to ensure that the dishes served are as tasty as possible; optimal portion sizing; sending leftover food to those in need or selling it at a reduced price; paying increased attention to stock management; and implementing self-service systems.

Regarding the *third research question*, the thematic analysis uncovered several themes related to respondents' perceptions of government involvement and the measures that could be taken to support HoReCa units in minimizing food waste. Respondents expressed a desire for new measures, innovative and pragmatic solutions to support HoReCa units in their efforts to reduce food waste. These expectations include financial support through subsidies for purchasing equipment, along with continuous monitoring to ensure that the recipients use the equipment for the intended purpose. Active government involvement constitutes the second most frequently identified theme in the thematic analysis, holding an important position alongside the first theme. This reflects the respondents' perception that the government plays an essential role in implementing food waste reduction strategies.

The thematic analysis of the *fourth research question* highlighted four important themes. The highest frequency of codes is found in the theme related to portion adjustments based on customer requirements. Portion adjustments based on customer demands are a central practice in the HoReCa sector, allowing portion sizes to be tailored to the preferences and needs of different customer segments.

The thematic analysis of the *fifth research question* includes four important themes. The most significant theme refers to the availability of special and themed menus. The introduction of special and themed menus in the HoReCa sector reflects a major concern among respondents for customizing culinary offerings, adapting to various events and special needs to enhance the customer experience from both a health and resource-saving perspective, including time and financial resources.

The thematic analysis of the *sixth research question* revealed six important themes. The most dominant of these is the correlation of production with demand. Production based on demand is seen by respondents as extremely important in the context of optimizing production and resources. Adapting production to real demand (based on specific menu

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items, recent trends, etc.) allows for the avoidance of overproduction through efficient resource use, ultimately reducing food waste.

The thematic analysis of the *seventh research question* includes five important themes. The most dominant themes are those related to the development of delivery services, rethinking stock management, and reducing the number of dishes on the menu. The first three themes highlight how HoReCa units were forced to be swift and innovative in addressing the challenges brought by the COVID-19 pandemic, adapting their operating processes to stay in business and reduce food waste. As restaurants faced restrictions on in-house dining, the development of delivery services became essential for maintaining operations.

The *eighth research question* is supported by the identification of six important themes. The most dominant themes refer to increased profitability and optimized resource use. The two central themes are evidently interconnected, reflecting an integrated approach to the benefits derived from reducing food waste in the HoReCa sector. Increased profitability underscores the direct link between reducing food waste and boosting profits.

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Chapter 4. Complementary studies on food waste management in the preparation, serving, and consumption stages using PLS-SEM and fsQCA methods

Understanding and identifying the root causes of food waste is crucial, as efficient food waste management, through the application of specific strategies, requires a deep understanding of the origin of these causes. The outcome of food waste management actions provides both financial and sustainability benefits. In the HoReCa sector, food waste is mainly generated during preparation, serving, and consumption. Food preparation is the primary stage where food waste is generated, followed by the serving and consumption stages. Managers, staff, and customers of HoReCa units are the key actors involved in the food waste management process. In this regard, two studies were developed to encompass all of these three stages.

In the HoReCa sector, the main stage in which food waste is generated is during food preparation. Managers of HoReCa units are the primary decision-makers who can influence this phenomenon. Food waste during this stage can be influenced by multiple causes. The implementation of efficient management strategies can provide both financial and sustainability advantages.

Based on the theoretical framework regarding food waste during the preparation stage in HoReCa units, it was established that there are multiple causes of food waste. By implementing efficient management initiatives, the effects of these causes can be significantly reduced, resulting in important benefits from food waste reduction. The conceptual model consists of four reflective variables and initially aims to identify the impact of two variables, representing food waste management initiatives, on a variable representing the causes of food waste during the preparation stage, and the impact of this variable on another variable, which includes the benefits resulting from food waste reduction. In the second phase, the conceptual model aims to establish how the variable representing the causes of food waste during the preparation stage explains how or why the variables representing management initiatives and the resulting benefits, in the context of food waste reduction, are connected. The central consideration of the mediation analysis is that there is a significant relationship between the independent variables related to management initiatives and the resulting benefits, through the mediator variable related to

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causes in the preparation stage, in the context of food waste. The five research hypotheses describing the relationships between the variables are:

- ✧ **H1 (Hypothesis 1):** *Efficient portion management* (MEP) has a significant impact on the *causes of food waste during the preparation stage* (CRA)
- ✧ **H2 (Hypothesis 2):** *Optimization between production and sales* (OPV) has a significant impact on the *causes of food waste during the preparation stage* (CRA)
- ✧ **H3 (Hypothesis 3):** The *causes of food waste during the preparation stage* (CRA) have a significant impact on the *benefits of food waste reduction* (BRA)
- ✧ **H4 (Hypothesis 4):** The *causes of food waste during the preparation stage* (CRA) mediate the relationship between *efficient portion management* (MEP) and the *benefits of food waste reduction* (BRA)
- ✧ **H5 (Hypothesis 5):** The *causes of food waste during the preparation stage* (CRA) mediate the relationship between *optimization between production and sales* (OPV) and the *benefits of food waste reduction* (BRA).
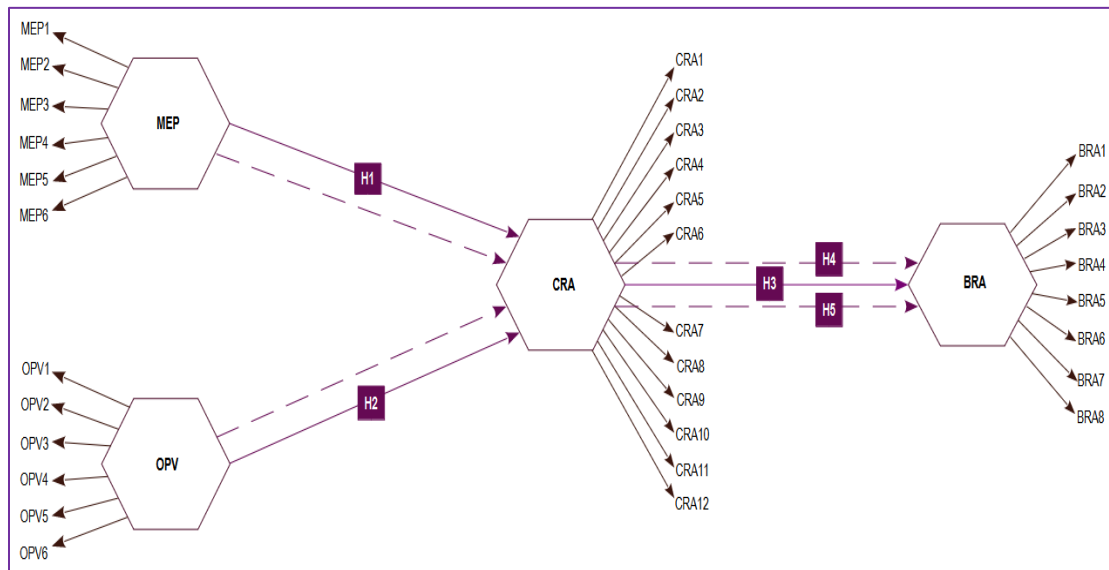

Figure 4.1. The conceptual model associated with the first study, based on the PLS-SEM method, and the research hypotheses
MEP – Efficient Portion Management; OPV – Optimization between production and sales; CRA – Causes of food waste during the preparation stage; BRA – benefits of food waste reduction
Source: own contribution

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The structure of the conceptual model includes the relationships between variables and indicators (items or manifest variables). A series of specific indicators were identified for each variable, which are effect indicators (associated with the reflective variable). These represent the available data, collected through the questionnaire, used in the measurement model to assess the four latent variables: MEP, OPV, CRA, and BRA (Figure 4.1).
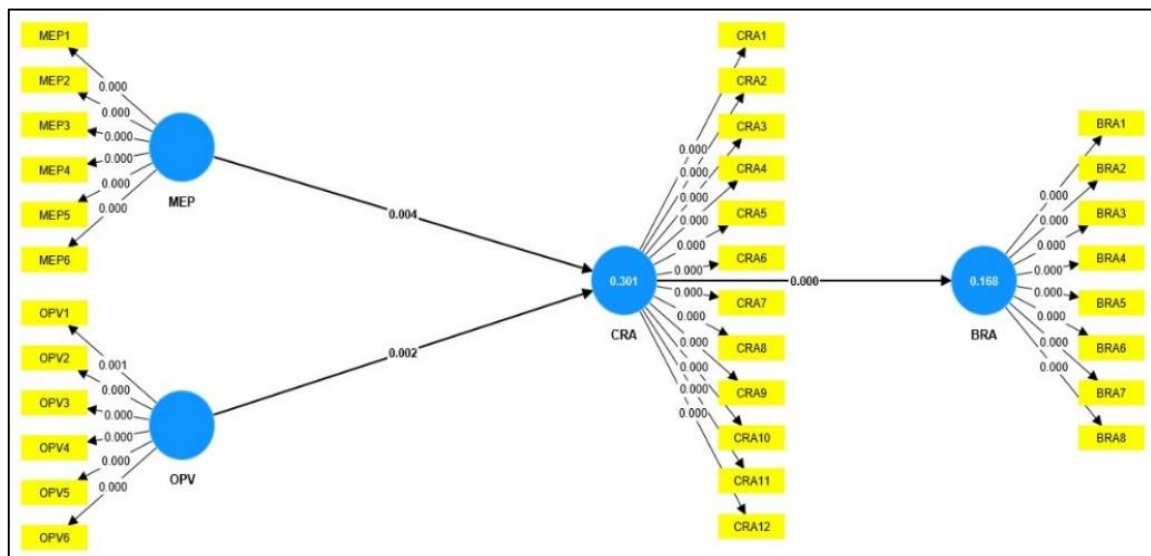

Figure 4.2. Determination of p-values associated with the relationships between the variables in the model from the first study
Source: Smart PLS 4 software report

Figure 4.2 illustrates the structural model generated after applying the bootstrap procedure, where the p-values are highlighted on the link relationships between the latent variables. All five hypotheses proposed in the research model were validated. Thus, efficient portion management and optimization between production and sales have a significant impact on the causes of food waste during the preparation stage. The causes of food waste during the preparation stage have a significant impact on the benefits of food waste reduction. Additionally, they mediate the relationships between efficient portion management, optimization between production and sales, and the benefits of food waste reduction. The mediation hypotheses were validated because the p-values were below the 0.05 threshold, and the value 0 did not fall between the lower and upper limits of the adjusted confidence interval (Table 4.1).

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Table 4.1. Asymptotic significance p-values and t-test values for the two mediation hypotheses in the structural model (total indirect effects)

Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Adjusted Confidence Interval	
						LB (2.5%	UB (97.5%)
MEP -> BRA	0.129	0.137	0.060	2.171*	0.030	0.036	0.264
OPV -> BRA	0.118	0.127	0.050	2.336*	0.020	0.031	0.220

Source: processed from SmartPLS 4 software data (Note: * t-value >1.96; LB = lower bound; UB = upper bound)

The Quine-McCluskey algorithm is a method used for minimizing Boolean functions, which provides three types of solutions. Among these, the complex solution presents all possible combinations of conditions. In this case, the algorithm identifies two solutions (the symbol "~" represents the absence or low impact of a condition) (Table 4.2).

Table 4.2. The complex solution provided by the Quine-McCluskey algorithm for the sample of HoReCa unit managers

Complex solution	Raw coverage	Unique coverage	Consistency
~cCRA	0.4085	0.0063	0.8690
cOPV	**0.9584**	**0.5561**	**0.9313**
Solution coverage score: 0.9647			
Solution consistency score: 0.8971			

Source: processed from fsQCA software data

This analysis shows that the presence of the cOPV condition is highly relevant (approximately 95.8% of the cases are explained by its presence) and has a high consistency (0.931) in predicting the cBRA outcome, indicating a strong relationship. The low presence of the cCRA condition (approximately 40.8%) also contributes to explaining the outcome, but to a lesser extent. The overall solution is strong, with a high coverage (about 96.5% of cases) and very good consistency (almost 90%), suggesting the relevance and predictability of the identified condition combinations in the context of the research. Thus, a low level of cCRA and a high level of cOPV contribute to cBRA, with cOPV being the most influential predictor of cBRA, which reinforces the PLS-SEM results.

The next stages, immediately after food preparation, in which food waste is generated, are serving and consumption. Staff and customers of HoReCa units represent two additional key categories of actors involved in the food waste management process. In these two stages as well, food waste can be caused by a multitude of factors, and

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implementing efficient management strategies can lead to financial and sustainability benefits (which can be felt by all parties involved in this process). Through the feedback of HoReCa unit customers, the full picture of food waste management can be completed across all three stages, from food preparation to serving and consumption. The perspective of HoReCa customers not only reveals their behavior but could also highlight certain actions and management initiatives related to food waste, taken by the staff, giving unit managers a clear and comprehensive view to successfully address food waste issues throughout the entire process.

In the serving and consumption stages of HoReCa units, a multitude of causes generating this phenomenon have also been identified. By applying efficient management initiatives, the effects of these causes can be significantly reduced, leading to important benefits from food waste reduction. The conceptual model comprises five reflective variables and initially aims to identify the impact of three variables representing food waste management initiatives on a variable representing the causes of food waste in the serving and consumption stages, as well as the impact of this variable on another variable encompassing the benefits resulting from food waste reduction. In the second phase, the conceptual model seeks to establish how the variable representing the causes of food waste in the serving and consumption stages explains how or why the variables representing management initiatives and the resulting benefits in the context of food waste reduction are connected. The central consideration of the mediation analysis is that there is a significant relationship between the independent variables related to management initiatives and the resulting benefits, through the mediator variable representing the causes in the serving and consumption stages in the context of food waste. The seven research hypotheses describing the relationships between the variables are:

- ✧ **H1 (Hypothesis 1):** *Efficient portion management* (MEP) has a significant impact on the *causes of food waste in the serving and consumption stages* (CRA);
- ✧ **H2 (Hypothesis 2):** *Staff training* (IP) has a significant impact on the *causes of food waste in the serving and consumption stages* (CRA);
- ✧ **H3 (Hypothesis 3):** *Leftover food management* (MPR) has a significant impact on the *causes of food waste in the serving and consumption stages* (CRA);
- ✧ **H4 (Hypothesis 4):** The *causes of food waste in the serving and consumption stages* (CRA) have a significant impact on the *benefits of food waste reduction* (BRA);

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⬦ **H5 (Hypothesis 5):** The *causes of food waste in the serving and consumption stages* (CRA) mediate the relationship between *efficient portion management* (MEP) and the *benefits of food waste reduction* (BRA);

⬦ **H6 (Hypothesis 6):** The *causes of food waste in the serving and consumption stages* (CRA) mediate the relationship *between staff training* (IP) and the *benefits of food waste reduction* (BRA);

⬦ **H7 (Hypothesis 7):** The *causes of food waste in the serving and consumption stages* (CRA) mediate the relationship between *leftover food management* (MPR) and the *benefits of food waste reduction* (BRA).
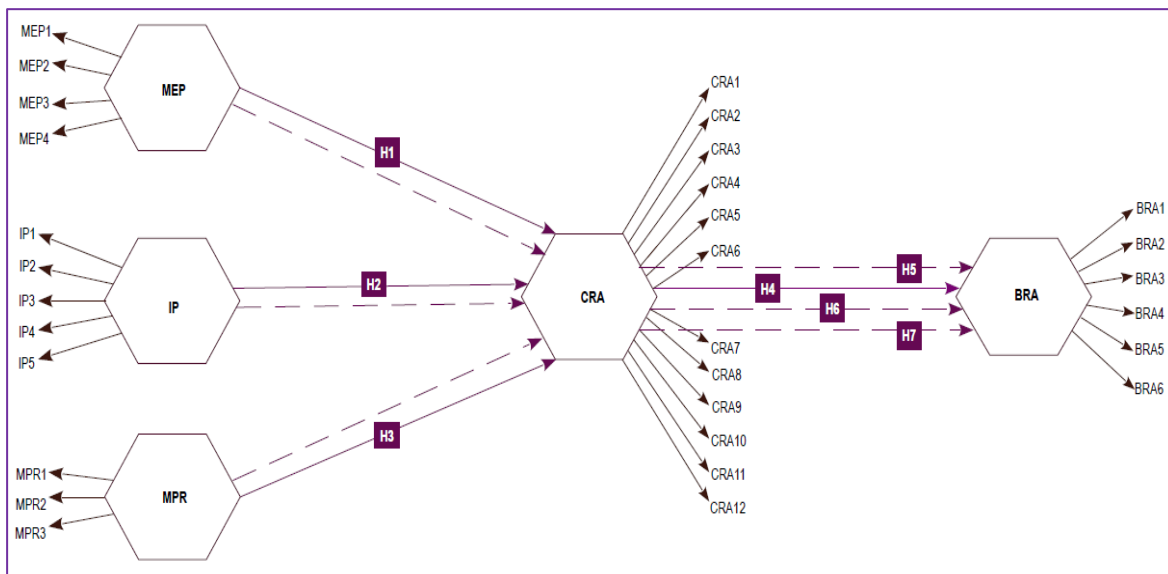

Figure 4.3. The conceptual model associated with the second study, based on the PLS-SEM method, and the research hypotheses
MEP – Efficient Portion Management; IP – Staff Training; MPR – Leftover Food Management; CRA – Causes of Food Waste in the Serving and Consumption Stages; BRA – Benefits of Food Waste Reduction
Source: own contribution

The structure of the conceptual model includes the relationships between variables and indicators (items or manifest variables). A series of specific indicators was established for each variable, these being effect indicators, meaning indicators associated with the reflective variable. The indicators represent the available data, collected through the questionnaire, used in the measurement model to assess the five latent variables: MEP, IP, MPR, CRA, and BRA (Figure 4.3).
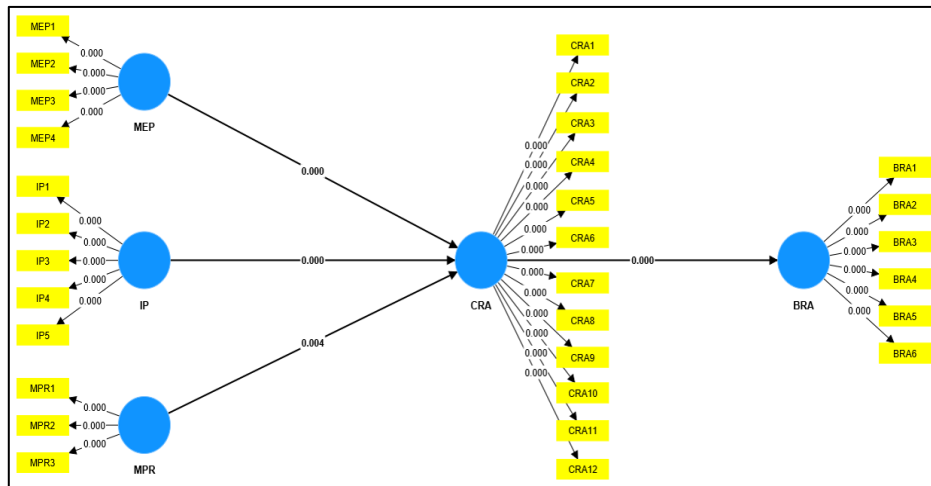
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Figure 4.4. Determination of p-values associated with the relationships between the variables in the model from the second study
Source: SmartPLS 4 software report

Figure 4.4 illustrates the overall structural model, after applying the bootstrap procedure, where p-values are highlighted on the link relationships between the latent variables. All seven hypotheses proposed in the research model were validated. Thus, efficient portion management, staff training, and leftover food management have a significant impact on the causes of food waste in the serving and consumption stages. The causes of food waste in the serving and consumption stages have a significant impact on the benefits of food waste reduction. Additionally, they mediate the relationships between efficient portion management, staff training, leftover food management, and the benefits of food waste reduction. The mediation hypotheses were validated because the p-values were below the 0.05 threshold (Table 4.3).

Table 4.3. Asymptotic significance p-values and t-test values for the three mediation hypotheses in the structural model (total indirect effects)

Relationship	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values	Adjusted Confidence Interval	
						LB (2.5%)	UB (97.5%)
MEP -> BRA	0.141	0.142	0.029	4.883*	0.000	0.060	0.187
IP -> BRA	0.117	0.119	0.033	3.582*	0.000	0.060	0.187
MPR -> BRA	0.077	0.078	0.030	2.515*	0.012	0.024	0.143

Source: processed from SmartPLS 4 software data (Note: * t-value >1.96; LB = lower bound; UB = upper bound)

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Among the three types of solutions resulting from the application of the Quine-McCluskey algorithm, the complex solution reveals all possible combinations of conditions. In the current research, the algorithm highlights seven solutions (Table 4.4).

Table 4.4. The complex solution provided by the Quine-McCluskey algorithm for the sample of HoReCa unit customers

Complex solution	Raw coverage	Unique coverage	Consistency
~cMEP*~cIP	0.1980	0.0065	0.8580
cMEP*cIP	**0.7576**	**0.0031**	**0.9774**
cCRA*cMPR	**0.7682**	**0.0113**	**0.9776**
cCRA*~cMEP	0.3127	0.0010	0.9780
~cMEP*cMPR	0.3364	0.0026	0.9797
cCRA*cIP	**0.7589**	**0.0016**	**0.9801**
cIP*cMPR	0.8842	0.0516	0.9720
Solution coverage score: 0.9238			
Solution consistency score: 0.9369			

Source: processed from fsQCA software data

Considering both consistency and coverage, the three most important solutions are: cCRAcIP (with approximately 98% consistency and nearly 76% coverage), cCRAcMPR (with nearly 98% consistency and approximately 77% coverage), and cMEP*cIP (with about 98% consistency and nearly 76% coverage). These combinations represent cases that lead to the result (cBRA) to a very high degree (about 98%), and a significant proportion (76-77%) of all cases in which the result occurs can be explained by these combinations. Thus, the first two solutions reinforce the PLS-SEM results by highlighting that the variable CRA is a central point in the causal chain of food waste reduction. The idea is emphasized that in achieving the BRA variable, CRA does not function in isolation, but the efficiency of obtaining the result depends on how the IP and MPR variables have an effect.

Furthermore, the PLS-SEM results are complemented by the third solution, which highlights the confirmation of the extremely important role of the MEP variable in combination with the IP variable, extending beyond its individual role. This integrated approach suggests that the maximum efficiency of the MEP variable could be achieved when combined with the IP variable. For the optimal fulfillment of the BRA variable, both variables should be considered.

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Chapter 5. Conclusions, implications of the research, original contributions, limitations, and research directions regarding the improvement of food waste management in the HoReCa sector

The combined use of qualitative and quantitative studies allowed for a deep and nuanced analysis of food waste in the HoReCa sector. The Nvivo software provides a detailed qualitative understanding of the studied phenomenon, while approaches processed through SmartPLS and fsQCA software offer quantitative and mixed-method perspectives, enabling the testing of hypotheses and the exploration of complex relationships between variables.

This doctoral thesis makes important contributions in the practical area by providing HoReCa managers with a set of practical tools to reduce food waste, gain significant advantages, and achieve long-term sustainability.

Optimization between production and sales proves to be essential for reducing food waste during the preparation stage. Adopting the FIFO method and utilizing modern technologies, such as artificial intelligence and predictive analytics, facilitate purchases based on actual and forecasted demand. Subsequently, stocks and production are adjusted to prevent the accumulation of surpluses and overproduction, thus ensuring efficient resource (ingredient) management and improving operational efficiency. Therefore, purchases and production must be synchronized with real and estimated demand to maintain a balance between available resources and final products. In addition, using smart storage equipment to maintain food freshness is an essential practical measure to support these optimizations. These devices enable precise management of storage conditions, thus extending the shelf life of food and preventing premature spoilage.

Efficient portion management, through adjustments, including portion size based on customer requirements and offering flexible options (small, medium, and large portions at different prices), significantly contributes to reducing food waste during the serving and consumption stages. By tailoring portions to the actual needs and preferences of customers, HoReCa units can ensure more efficient use of food resources and significantly reduce the amount of uneaten food. Moreover, reducing portion sizes is a key factor in food waste management initiatives, supported by both managers and customers. These measures are particularly relevant for uneaten food left on plates, but they can also help prevent overproduction, along with menu simplification, which involves reducing the diversity of

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ingredients and downsizing buffet areas. However, it is crucial to gradually reduce portion sizes, and the introduction of themed and special menus (e.g., daily menus, smart menus) allows for the creative and sustainable use of resources and adapts the offering to customer requirements (menu simplification could be seen more as an initiative during uncertain times, such as the COVID-19 pandemic). To enhance these initiatives, continuous staff education and training are vital for advising customers on choosing dishes that suit their needs and preferences. Additionally, education should extend to customers through awareness campaigns that promote responsible consumption behaviors.

The implications are also broadened through initiatives that target the next level in the food recovery hierarchy (if food waste has not been sufficiently reduced through source reduction measures). Regarding food redistribution, initiatives focused on donating unsold but still consumable food and selling leftovers to customers or employees at reduced prices, just before closing, should be integrated into the operational strategy of HoReCa units.

Besides practical contributions, the thesis also brings theoretical implications deeply rooted in food waste management, sustainability, the circular economy, and operational management in the HoReCa sector. By developing a general framework for food waste management, this doctoral thesis significantly contributes to expanding the existing literature on food waste management within the context of the circular economy.

Moreover, the doctoral thesis emphasizes the importance of food waste management in the HoReCa sector, not only from an economic and operational perspective but also in terms of the significant social impact that these strategies can have on society. First, the research highlights how the implementation of efficient food waste prevention and redistribution initiatives contributes to reducing social inequalities. Thus, by directing food to people in need, food insecurity is reduced, vulnerable communities are supported, and stronger social cohesion and reduced economic disparities are achieved.

Although food waste is a frequently discussed issue and a key challenge, its management tends to be isolated, lacking an integrated approach that focuses more on prevention rather than recycling. While some studies have focused on the amount of food wasted in different types of HoReCa units, and others have described the causes of food waste, measures to reduce it, and the resulting benefits, no study has concretely addressed the causal relationships between measures, causes, and benefits. Furthermore, the specialized literature is limited regarding a combined causal approach—direct, at the individual level, and indirect, at the level of complex causal relationships—in the context of food waste management. This doctoral thesis stands out for its unique and innovative approach, primarily focused on prevention, which combines structural equation modeling

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with fuzzy set qualitative comparative analysis (fsQCA) to explore the complex causal relationships in food waste management in the HoReCa sector. This multi-methodological approach not only enhances predictive power but also provides a more detailed perspective on the interdependencies between the variables involved (measures – causes – benefits). Unlike other studies, this research integrates a detailed analysis of the specific stages of the food process, from preparation to serving and consumption, making a distinct contribution to food waste management.

While the doctoral thesis makes valuable and significant contributions to understanding and managing food waste in the HoReCa sector, it has certain limitations that could influence the generalizability and applicability of the results, as is common in academic studies: generalizability of results, sample size, methodological limitations, temporal perspective, and conceptual boundaries.

Based on the results obtained, the following directions for future research on food waste reduction can be outlined: extending food waste reduction methods in the post-pandemic context, integrating digital technologies in food waste management, analyzing the impact of public policies on food waste, exploring cultural factors in food waste reduction, conducting comparative studies on the effectiveness of food waste management solutions, and including longitudinal studies.

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