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**Consumer analysis of upcycled foods:
a survey-based study on Italian consumers**

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TITOLO TESI

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ABSTRACT

The increase in food waste over recent decades has led to significant environmental, resource, and socioeconomic challenges, exacerbating food insecurity and greenhouse gas emissions. This thesis explores upcycled foods as an innovative solution within the circular economy framework to address these issues. The research aims to understand consumer responses, assess factors affecting acceptability, and investigate attitudes and intentions towards upcycled foods. Through a comprehensive and systematic literature review, meta-analysis, and empirical study, the thesis reveals generally positive consumer perceptions of upcycled foods, albeit with declining enthusiasm from attitudes to actual purchase intentions. The meta-analysis confirms a significant positive combined effect of various factors on consumer acceptability of upcycled foods. An empirical study in Italy, using the Theory of Planned Behavior, identifies key influences on attitudes and intentions, including traditionality, food neophobia, subjective knowledge, and environmental concerns. Notably, the research uncovers an attitude-intention gap among Italian consumers, mirroring findings for other innovative foods. This multifaceted analysis provides valuable insights into consumer behavior towards upcycled foods, contributing to the broader understanding of food waste reduction strategies and sustainable consumption patterns. The findings have important implications for policymakers, food industry stakeholders, and researchers working towards more sustainable food systems.

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Abbreviations and Acronyms

UF	Upcycled foods
UFA	Upcycled food association
AFS	Agri-food sector
UNO	Nations organization
FAO	Food and agriculture organization
EUFIC	European food information council
SDGs	Sustainable development goals
CE	Circular economy
SRM	Secondary raw material
EU	European Union
ICESP	Italian circular economy stakeholder program
ECESP	European circular economy stakeholder program
INEST	Interconnected North-East Ecosystem
TPB	Theory of planned behavior
PRISMA	Preferred reporting items for systematic review and meta-analysis
TFQ	Total food quality model
CI	Confidence interval
REM	Random effect model
REML	Restricted maximum likelihood
FN	Food neophobia
HC	Health consciousness
EC	Environmental concerns
TD	Traditionality
AT	Attitude
INT	Intention
SK	Subjective knowledge
SN	Social norms
BC	Behavioral control
CB-SEM	Covariance based structural equation modeling
AVE	Average variance extracted
FLV	Fornel larker values

WTP Willing ness to pay

WTB Willingness to buy

WTA Willingness to Accept

CRVE Cluster robust variance estimator

RBF Rescue based foods

GPV Green perceived values

MA Mata analysis

SUMMARY

Over the past few decades, food waste has increased to alarming levels, causing devastating environmental effects, squandering food resources, and creating numerous socioeconomic problems. With the world population expected to reach 9 billion by 2050, food waste is leading to food insecurity and significantly contributing to greenhouse gas emissions annually. In response, the European Union is taking numerous steps to mitigate food waste management. Applying circular economic principles in the agri-food sector is one of the most viable solutions to this problem. Based on these principles, transforming food by-products or leftover materials into edible, value-added foods—called upcycled foods—through "food waste upcycling" is the most advanced and innovative process among several conventional food waste valorization methods. Upcycled foods require consumer acceptability for market penetration and expansion, thus contributing to the food waste management loop. Given this scenario, this thesis has three main objectives: 1) to understand consumer responses towards upcycled foods, 2) to assess the factors affecting consumer responses towards upcycled foods, and 3) i) to determine consumers' attitudes and intentions towards upcycled foods, and ii) to identify the attitude- intention gap among consumers regarding upcycled foods.

To achieve the first objective, we conducted an extensive literature review using the Scopus database, employing specific keywords and following predefined inclusion and exclusion criteria. We selected only those research papers that analyzed consumer responses to upcycled foods, rescue-based foods, waste-to-value foods, or recycled foods. The results revealed that the main consumer responses identified were attitudes or perceptions, willingness to buy or purchase intention, willingness to pay, and sensory evaluation. While most responses were positive, they declined and showed heterogeneity when moving progressively from perceptions to actual buying intentions.

For the second objective, we conducted a meta-analysis. Regression coefficients were collected from respective studies, and the combined effect of different factors on consumer acceptability of upcycled foods was determined using a random effect model (REM). The effects of consumer perceptions about environmental impact, food product characteristics, and communication or information were also determined using a multilevel REM model in the meta-analysis. The results showed that the pooled effect of different factors on consumer acceptability was positive and highly significant.

The third objective was to determine consumers' attitudes and intentions towards upcycled foods and to assess the existence of a well-known behavioral gap called the "attitude-intention gap." We developed a theoretical model based on the Theory of Planned Behavior (TPB) and conducted a survey in Italy. Data was analyzed using structural equation modeling (SEM) to determine Italian consumers' attitudes and intentions towards upcycled foods. The results showed that, for Italian people, who are traditional in their food choices, traditionality had a negative effect on attitudes, and food neophobia negatively affected attitudes as expected. Other factors like subjective knowledge and environmental concerns led to positive consumer attitudes. However, an attitude-intention gap was found among Italian people, which is also confirmed in the case of other innovative or new foods.

Overall, this thesis thoroughly explains consumer responses towards upcycled foods, factors affecting consumer acceptability of upcycled foods, factors influencing consumer attitudes and intentions, and identifies and discusses the well-known "attitude-intention gap" for upcycled foods, which has already been observed in the case of other innovative foods.

1 INTRODUCTION

The agri-food sector (AFS) has been hit hard by problems such as population expansion, resource scarcity, food loss and waste along the global food supply chain. The inefficiency of the food sector results in loss of productivity, energy, natural resources, and the cost of managing these wastes. More pollution and greenhouse gases are also created because of these processes and the unsustainable consumer consumption patterns have contributed significantly to these problems (Jurgilevich et al., 2016; Esposito et al., 2020). In recent years, the agrifood system has begun to pay close attention to issues such as food safety and food security, food production traceability, especially with respect to the environment and human resources leading to a shift toward sustainable production and consumption methods. As a result, agribusinesses are now integrating sustainability into their business models due to increased attention from policy makers, scholars, and governmental organizations.

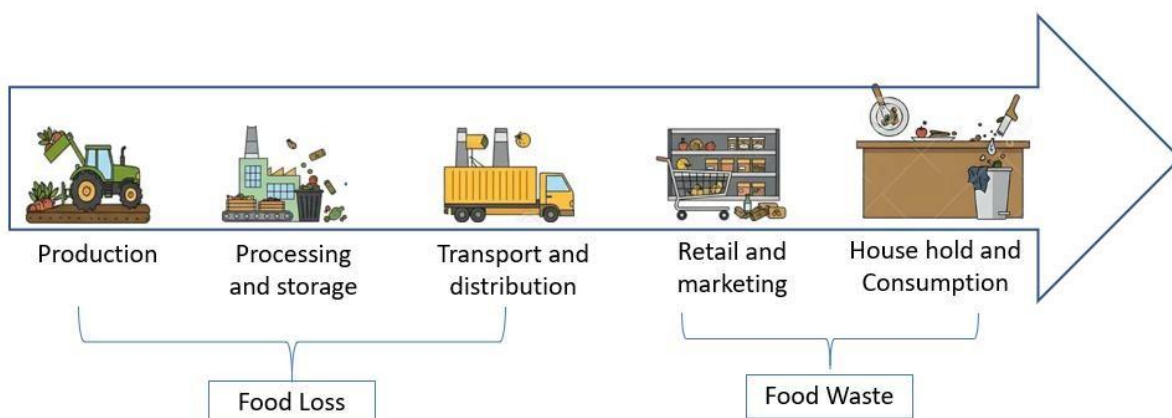
One of the biggest problems in the agri-food sector is the production of food waste; each year, about one-third of the food produced ends up in the trash of consumers and traders, or it deteriorates due to poor transportation systems or farming practices. When food is wasted, all the efforts used in production, transportation, processing and marketing are wasted, without gaining any benefit; in fact, food waste is one of the major contributors to the emission of greenhouse gases, thus having a negative impact on the environment (Grizzetti et al., 2013; Scherhauser et al., 2018; Jeswani et al., 2021).

The anticipated challenges in delivering sustainable, healthy, and sufficient food are expected to intensify as the global population is projected to reach approximately 9 billion by 2050 (Goswami and De. B., 2021). In this context, food waste represents a significant global challenge for sustainable food production and consumption. Approximately one-third of the total food produced is wasted or lost annually, leading to adverse consequences such as food insecurity, financial losses, and environmental degradation (Bond et al., 2013; Moshtaghian et al., 2023; Shafiee-Jood and Cai, 2016; Busetti and Pace, 2022). The annual global estimate of food waste is around 1.3 billion tons, occurring at various stages in the food supply chain, including production, storage, processing, distribution, retail, food service, and consumption (Heydari, 2024, Scherhauser et al., 2018; Xue et al., 2017, Mokrane et al., 2023), causing around 8%-10% global greenhouse emission (UN Climate Change 2024) and costs approximately 990 billion dollars annually (Andersen, 2021). In Europe,

according to Eurostat (2022), around 59 million tons of food waste are generated every year, with the highest level occurring at the household level making up to 32 million tons. Therefore, mitigating food loss and waste stands out as a pivotal objective for attaining a sustainable food system (Lindgren et al., 2018).

The food loss and food waste can be distinguished separately in such way that according to FAO (2019) the food loss is related to the decrease in the quantity or quality of food resulting from decisions and actions of food producers and food suppliers in the supply chain at the early stages and handling the foods at the harvesting, picking or collection stage. While the food waste is the decrease in food quantity or quality resulting from the decisions and actions by retailers, food service providers and consumers handling the foods during transport, storage, processing, distribution and consumption, which includes both individual and community waste from households, restaurants, canteens, and caterers. Whereas the quantity refers to the decrease in mass of food for human consumption, while quality refers to a decrease in food attributes that reduce its value in terms of intended use (FAO, 2019). Figure 1 shows all stages of the supply chain and the division between those where food waste and food losses materialize.

Figure 1 Food Supply Chain



Source: Author's elaboration

The food losses and waste come mainly from plant based and animal-based foods. Plant products can be exposed to losses caused by various factors including mechanical damage and spillage during harvesting, waste during harvesting, degradation and/or breakage during processing and handling such as washing, peeling, slicing or boiling. Storage, sorting by industry, market systems, and unsold or expired food during distribution can also contribute to these losses. When it comes to animal-based foods, food losses and waste mainly arise from livestock deaths during rearing due to

diseases, as well as deaths during transport, packing and storage. In the case of milk and its derivatives, losses occur due to possible diseases of dairy cows and mismanagement of quality and safety of milk and dairy products. In the case of fish, losses arise from cutting during processing and industrial transformation. In addition, it is important to note that while food losses during the early stages of the food chain are usually unintentional, those produced by distribution and consumers are almost intentional and caused by the wrong and negligent behavior of food distributors, handlers, sellers and consumers (Parfitt et al., 2010).

The loss and waste of food is not convenient from an environmental, social, and economic perspective. FAO (2011) states that while in middle- and high-income countries (industrialized countries) food is largely wasted even though it is still suitable for human consumption, in low-income countries (developing countries), on the contrary, food is mostly lost during the early stages of the supply chain. There are different reasons for these industrialized countries, food is wasted when production exceeds demand, as to ensure delivery of the agreed quantities in anticipation of unpredictable climate change and pest attacks, farmers end up producing more than necessary, albeit with lower quality products. Another cause of waste is the demand for products with high quality standards in terms of appearance, even when it is not a quality factor in terms of nutrition. Furthermore, large quantities of products on display and a wide range of different brands increase the likelihood that some of them will reach their expiration date earlier and therefore be thrown away.

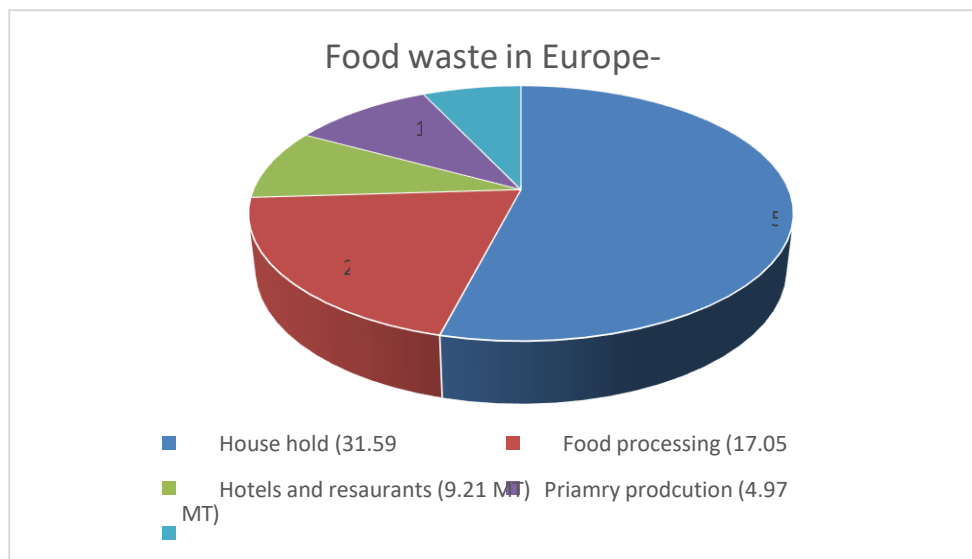
On the other hand in developing countries most of the food is lost as during harvesting instead of wasted due to poor farming practices, lack of technologies, inappropriate food shortages or desperate need for money, products are harvested in an inappropriate way due to lack of required technology thus causing a decrease in nutritional and economic value which can be wasted if not suitable for human consumption. Yet another cause could be the lack of storage facilities suitable for food preservation, a widespread problem in developing countries (FAO, 2011; Alamar et al., 2018).

Whereas, in the industrialized or developed countries, food is mostly wasted during the later stages of food supply chain, especially in the processing, storage and consumption sectors, i.e. food industries, hotels and restaurants or household levels. Therefore, the solution-oriented efforts should be more focused on the consumption side, and the people need to change their behavior towards food handling and storage and consumption (FAO, 2011, Thi et al 2015; Aschemann-Whitzel et al 2015; Ishangulyyev et al, 2019; Vos et al, 2019 from starvation due to insufficient availability of nutritious and adequate food, therefore food waste is a major threat to food security.

To better understand the magnitude of problems associated with food waste, it is useful to report some of the key statistics and facts on food wastes and losses from a 2021 report by the European Food Information Council (EUFIC, 2021) according to which the food waste alone generates about 8-10% of global greenhouse gas emissions, if food waste were a country, it would be the third largest emitter in the world only after China and the United States, the latest estimates indicate that about 931 million tons of food waste was generated worldwide in 2019, of which 61% came from households, 26% from catering and 13% from retail and about 59 million tons of food waste is generated in the Europe each year. This equals 174 kg per person, or 143 billion euros or 170 million tons of CO₂. The numbers in these statistics are very worrying from all points of view such as environmental primarily, social, and economic.

In addition to that according to the EUROSTAT DATA (2022), the percentage contribution of food waste throughout the various stages of food chain, from production to consumption, of Europe's total food waste production.

Figure 2 Food Waste at European level



Source: Eurostat, 2022

From the graph it can be seen that households have the greatest impact on waste generation (more than 50%), followed by industries, primary production, and finally retail and catering. This food waste at every stage of its production, transportation, and storage results in significant waste of resources. The data seen are staggering and as the world population is projected to increase,

consumption and waste of food will also increase, exacerbating the problem. Since the resources needed for food production are limited, it is imperative that they be used sustainably and efficiently (Tamasiga et al., 2022).

Considering the environmental, economic, and social implications of food waste, the first step toward a more sustainable solution is to adopt a sustainable production and consumption approach, without focusing only on the final part of the supply chain (Chiaraluce et al., 2021). This concept is also included in the Sustainable Development Goals (SDGs) of United Nation organization (UNO) out of which SDG number 2 deals with No hunger, sustainable production and consumption SDG:12 and climate action SDG:13 (Figure3) are the main agendas related to this thesis.

Figure 3 Sustainable development goals (SDGs)



Source: UNO

Among these goals it is important to highlight for the purpose of this thesis, the SDG number 12, that of ensuring sustainable patterns of production and consumption which aim to "do more and better with less," increasing the benefits in terms of economic well-being by reducing the resource use, degradation, and pollution throughout the production cycle, thus improving the quality of life (United Nations, 2015).

Sustainable consumption and production refer to an ideal model in which all actors in the food supply chain learn to use resources efficiently while minimizing waste by, for example, giving it a new life or exploiting it to get something more out of it. This includes actions to reduce the negative impact of food production and consumption on the environment, substantially reducing food waste generation through recycling or reuse, encouraging companies to adopt sustainable practices, and developing and implementing tools that monitor this transition to sustainability (Akenji et al., 2015).

The increase in the amount of food waste and the difficulties connected with its management are becoming a problem that can be effectively solved in accordance with the principles of the circular economy (Szyba & Mikulik, 2022). Excessive waste production is one of the consequences of the traditional linear production model in which materials are extracted, processed, consumed, and disposed of at the end of their short useful life because they are designed with a single purpose in

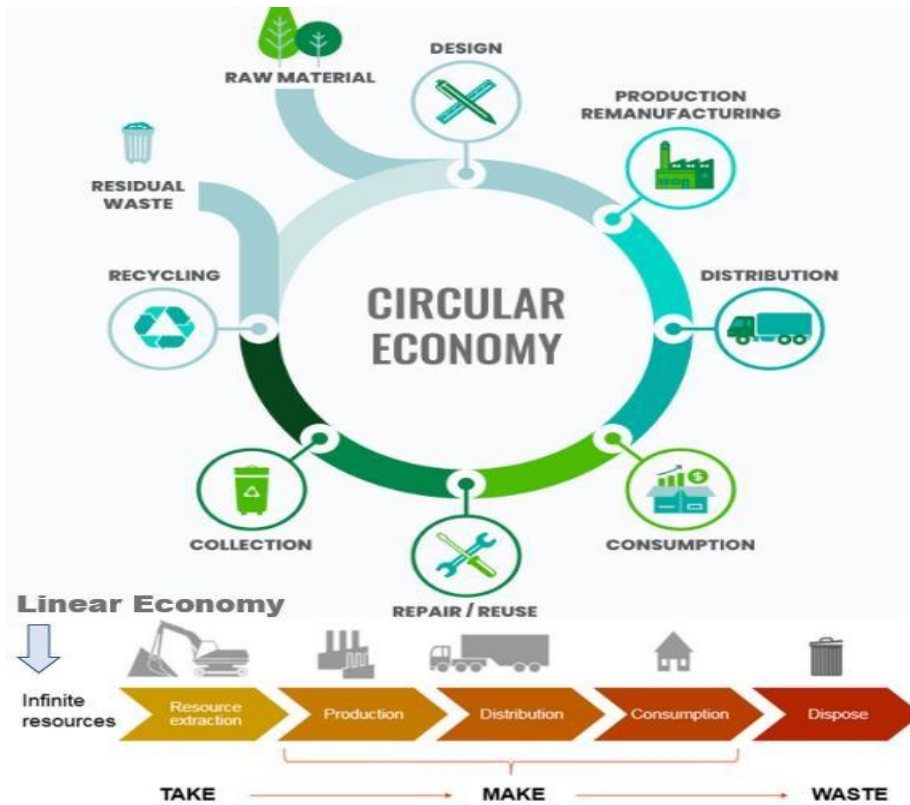
mind. This process, accelerated by economic development, has substantially increased the amount of waste generated, and it is precisely to limit the impact of this process that the idea of the circular economy was born, that of extending the life cycle of products as long as possible for the benefit of the environment (Neves & Marques, 2022).

1.1 Circular economy

The concept of circular economy (CE) originated in the 1970s with the goal of reducing resource consumption for industrial production, but it turns out to be potentially applicable to any resource. Through the possibility of making human activity more resilient, using the natural cycle model, CE proposes a change in the "extraction-production-disposal" paradigm of the linear economy (Arruda et al., 2021). In figure 4 the difference between the principles the linear economy and the circular economy are given.

According to Kirchherr et al., (2017) there are round 114 definitions of circular economy which have been reported, one of them, believed to be the most widely used is the one given by the Ellen MacArthur Foundation in 2013, which states, *"The circular economy is a restorative or regenerative industrial system by intention and design. It replaces the concept of end-of-life with restoration, moves toward the use of renewable energy, eliminates the use of toxic chemicals, which undermine reuse, and aims for the elimination of waste through superior design of materials, products, systems, and, within that, business models."* Moreover, Nobre and Tavares (2021) sought to provide another definition of circular economy, finalized by 44 circular economy specialists in their own words: *"The Circular Economy is an economic system that aims at zero waste and pollution during the life cycles of materials, from environmental extraction to industrial processing, and to final consumers, applying to all ecosystems involved. At the end of its useful life, materials return to an industrial process or, in the case of a treated organic residue, return safely to the environment as in a natural regeneration cycle. It operates by creating value at the macro, meso and micro levels and takes full advantage of the nested concept of sustainability. The energy sources used are clean and renewable. Resource use and consumption are efficient. Government agencies and responsible consumers play an active role by ensuring that the system functions properly in the long run"*. This is an articulate and comprehensive definition of the circular economy in that it creates a positive correlation between the three different aspects of environmental, industrial, and social, and pushes all stakeholders in the production chain up to the consumer to be active participants in this change.

Figure 4 Differences between linear and circular economy



Source: Author's own elaboration

In principle, it can be said that the concept of CE is based on the design of high-value, extended-use products, thus extending their lifespan. The focus is on creating multipurpose goods that can be reused in different ways throughout their useful life. A key principle is to ensure the orderly return of solid waste to the industrial sector, where it can be cost-effectively recycled and used as secondary raw materials. In addition, CE requires a systematic approach to supply chain management, taking into account the interconnectedness of energy production, material extraction, processing, storage, consumption and the natural environment. (MacArthur, E., 2013).

This concept has been accepted to address sustainability in public policy in governments such as those in the European Union and has been implemented as a national development strategy just like in China (Arruda et al. 2021). Driven by population growth estimated at 9 billion people by 2050, serious anthropological and environmental impacts such as declining biodiversity and shortages of raw materials. Another view of the circular economy is the one encapsulated in the principle of the 3Rs (reduce, reuse, and recycle). The first R "reduce" is about efficiency in the production and consumption of resources, The second R of "reuse," implies a cyclical business model in which a

resource is regenerated or repaired to be used again, it can only be successful if consumers are then willing to purchase these goods, and to this end, companies need to invest further in marketing and public institutions need to educate and empower people. Finally, the third R for "recycle" refers to any recovery operation in which waste is reprocessed into new products for the same or different purpose. Among several possible solutions to the problem of food waste, the circular economy is a concept that has been given increasing attention, due to resources, which are not infinite, are exploited to their fullest potential thus reducing their negative impacts (Kristensen & Mosgaard, 2020). Thus, the goal of the circular economy replaces the concept of waste with that of a resource in order to reduce the consumption of raw materials and increase efficiency in the use of materials to maximize reuse and recycling.

In this context, the linear model of production and consumption needs to be radically redesigned, pushing the consumers to CE products as a potential solution to these challenges (Esposito et al., 2020). However, this transition from the traditional economy also depends on cultural and behavioral changes in that turning waste into resources is a complex and long-term process that requires a change of mindset on the part of the entire community that must proactively collaborate in this transition process (Neves & Marques, 2022). In this way the role of consumers in adopting this kind of sustainable but new and innovative system can be challenging, therefore, the focus of this thesis is particularly on the consumer analysis of upcycled foods which are produced by following the circular economic principles.

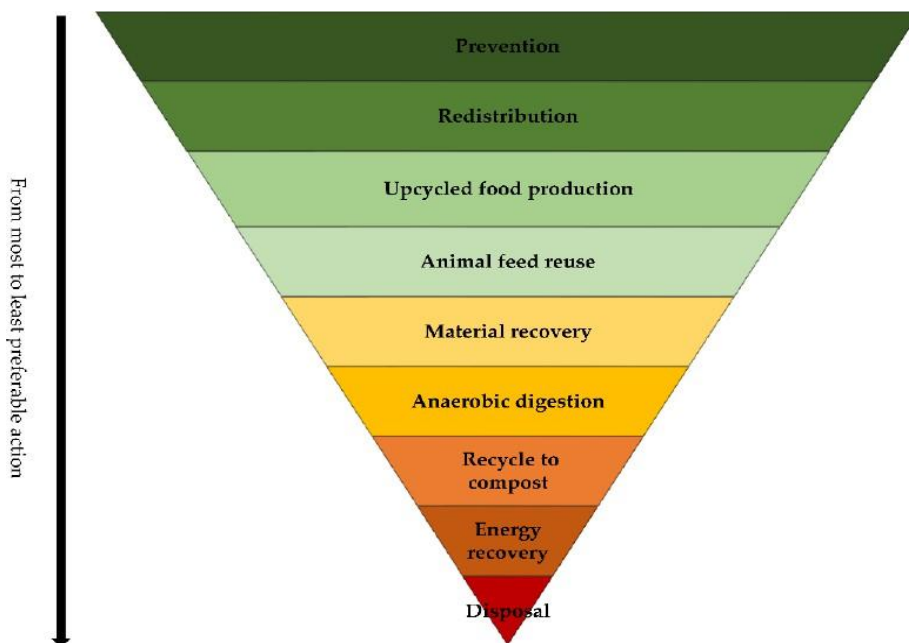
1.2 Circular economy at European and Italian level

The European Union and Italy have adopted various legislative policies specifications to encourage and regulate the implementation of the circular economy. In 2011, the European Union published a communication regarding the efficient use of resources. Within this communication, one of the measures identified to support this objective was the circular economy approach, which aimed to reduce waste generation and reuse waste as a resource. Four years later, in 2014, the European Union took a more definitive position on the issue with the communication "Towards a circular economy: a zero-waste program for Europe". This document placed great emphasis on the importance of adopting circular economy practices to address global resource scarcity and promote sustainable economic growth that is not tied to resource consumption. The European Commission has outlined several measures in these documents to promote resource efficiency and establish a circular system (Domenech et al., 2019; Zarba et al., 2021). These measures include creating a new policy framework, allocating funds for investment, and modernizing waste policies. The ultimate

goal is to extend the life of products and eliminate waste to keep their value for as long as possible (Chiaraluce, 2021). Subsequently, the European Commission started to develop policies focused on the circular economy from 2015 onwards with the first Circular Economy Action Plan (CEAP) entitled “Closing the loop - An EU action plan for the Circular Economy” was launched. This was updated in 2020 and mainly deals with the climate action.

Regarding waste, the Commission emphasizes the prominent role of waste management in the circular economy. In this regard, the commission recalls the waste hierarchy, an order of priority contained in the Waste Framework Directive (Directive 2008/98/EC), which establishes a set of preferential methods for managing waste with the lowest possible environmental impact. To this end the Food Waste Hierarchy (figure 5) aims to serve as a guide to establish the most appropriate options to address the challenge of managing food waste (Moshtaghian et al. 2021).

Figure 5 - Food waste Management Hierarchy



Source: Moshtaghian et al., (2021).

Considering consumption, the European Commission stresses the importance of the role of consumers in this transition, which has direct or indirect effect on the resource utilization. It becomes important to inform them clearly and accurately in order to raise their awareness of avoiding and reducing waste, preferring more sustainable products. An example could be the campaigns promoting voluntary EU Ecolabel, which identifies products with a reduced environmental impact.

Another topic covered in this action plan is the promotion of secondary raw materials (SRM), i.e., recovery materials that can be fed back into the production processes and economic system as new raw materials. In this regard, the European Commission proposes to develop a common methodology, together with all Member States to implement awareness campaigns for consumers along with the dissemination of good practices on food waste prevention by creating a platform dedicated to this issue that will function as a meeting point between the States to exchange information on this issue and propose innovations to achieve this goal.

Furthermore, to enhance consumer participation in the circular economy, the Commission proposed a revision of EU consumer legislation to ensure that consumers receive reliable and relevant information of products lifespan and availability of services repair kits, spare parts, and repair manuals. In addition, the Commission has taken into consideration consumer protection against ecological changes. According to Circular economy Network Italy the global material use has more than tripled over the past forty years, from 27 billion tons in 1970 to 98 billion tons in 2018. The European industrial economy is highly vulnerable, as these raw materials are strategic imports for the European Union and Italy being the second largest manufacturer in EU, its one of the most vulnerable to resource depletion due to dependence on foreign countries.

Therefore Italy has approved a series of political and legislative actions towards the adoption of the CE in the country such as the law 221 (December 28, 2015) and recent document from 2017, called "Towards a circular economy model for Italy", by the Ministry of the Environment and the Ministry of Economic Development (Ghisellini & Ulgiati, 2020). Following the UNO agenda 2030, in 2017, following the publication of the first Circular Economy Action Plan, the "Bioeconomy Strategy" was released. The aim was to implement sustainable production using renewable resources and the re-evaluation of waste and also to integrate coherently the principles of the bioeconomy and the circular economy to create business models that are economically sustainable in the long term. The national government has adopted various legislative decrees to implement the European Directives derived from the Circular Economy Package. The Legislative Decree 116/2020 indicates that the "National Waste Prevention Program" has been implemented to promote waste prevention. The program has established specific qualitative and quantitative indicators and targets since 2013 to evaluate the effectiveness of waste reduction. In particular, for the agri-food sector, it defines specific measures for the use of by-products and the promotion of short supply chains, also encouraging the donation of surplus products. In addition to that, according to the Decree 264/2016 a by-product is not wasted if the substance is the result of a manufacturing process and the substance which can be used in other processes, it can be used further in industrial process, and its further use is legal. Subsequently, the Italian circular economy stakeholder program (ICESP) was

born in 2018, the aim of which is to create a point of national convergence on initiatives, experiences, critical issues, perspectives, and expectations on the circular economy, mirroring the European circular economy stakeholder program (ECESP) platform (Chiaraluce, 2021). Furthermore, Italy introduced “The national circular economy strategy July 2022” to establish innovative methodologies and approaches to improve the secondary raw materials or by products market and ensure its competitiveness by focusing on both administrative and fiscal aspects. In addition to that to expand the secondary raw material market, improve the waste traceability and to enhance the circular skills and innovation. As far as the food sector is concerned, the strategy aims to reduce food waste by promoting the farm to fork strategy, and also include measures on food distribution, elimination of packaging and disposable.

1.3 Application of circular economy in agri-food sector

As previously mentioned, food waste is also a threat for food resources and sustainability of agri-food system and food is wasted throughout the supply chain, but the most part of food waste stream is generated at the end of the food chain by consumers. There are three main food waste mitigation strategies.

Animal and poultry feed

The first one is to use the food waste as feed for animals, poultry and fish which is also called traditional upcycling of the agriculture and food waste (Bangar et al 2024). Food waste upcycling for animal feed is a viable option, which could address food waste management issues at the same time food security and resource and environmental challenges (Dou et al., 2018; Shurson, 2020; Rajeh et al., 2021). This is a traditional method in which the administration of food waste and food production residues to farm animals are being practiced for many years in some parts of the world (Westendorf, 2000).

Biogas production

Another important example of an agrifood waste valorization can be the production of biogas. Biogas is a mixture of methane (40–80%), carbon dioxide (16–48%) and other trace gases, obtained from the fermentation of organic waste i.e. animal manure, fruits and vegetable waste etc. which can be used as an energy source in many sectors. A study by the World Bank has shown that around

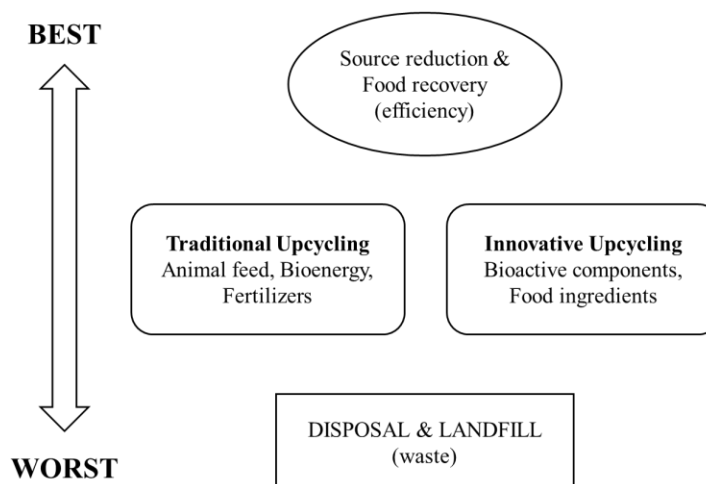
50% of the organic waste produced could be used for the production of biogas. Biogas plants are a very economical and beneficial way to manage organic waste generated in the agribusiness and municipal sectors because they reduce the amount of greenhouse gases (methane) emitted into the atmosphere, which is utilized in energy production instead (Szyba & Mikulik, 2022).

Food waste upcycling

Food waste upcycling into production of valuable products is another recent and appropriate method to valorize the food waste or leftover food materials or food by products into manufacturing of other value added, innovative and upcycled foods (UFs), according to Bangar et al. (2024) this innovative food waste upcycling is a unique and most advanced strategy to create value-added foods. In this strategy the food by products or materials are utilized to produce new food products before going to the disposal or landfills Figure.6.

When food by products, or inedible components of foods exit the food supply chain they end up in various destinations including landfills, water streams or hips of organic waste left unaltered. In addition to the other main valuable processes previously discussed, these food components are diverted to a new value added life in which they are made capable of feeding more people, putting less ecological pressure on and improving resource efficiency. Diverting this food by products or left over food materials and repurposing it into a new types of food materials called “upcycled ingredients”. These upcycled ingredients can be used to create new foods for human consumption. These new foods produced by the addition of the upcycled ingredients partially or completely are called upcycled foods and this process is called food upcycling.

Figure 6 Approaches of Food waste management



Source: Adapted from Bangar et al. (2024)

The foods which are produced from innovative upcycling are value-added foods created by applying different food technologies and can also be classified as 'green foods'. Indeed, while a precise and consensual definition of 'green foods' is difficult to retrieve (de Sio et al. 2024; Durif et al. 2010), this term usually indicates a broad category of food products that have a lower environmental impact throughout their entire life cycle (de Sio et al. 2024; Paul et al. 2016). In this respect, their alignment with circular economy principles ensures that upcycled foods (UFs) increase the efficiency of the use of resources, with potential environmental benefits (Moshtaghiyan et al., 2024).

There are several food by-products which can be obtained from the food waste like cereals to obtain fibers, hemicelluloses, beta-glucans and prebiotic oligosaccharides, fruits and vegetable peels, seeds, pulp can be the source of polyphenols and organic acids, pectin carotenoids, polyphenols, oils by products can be obtained from seed cakes from seed oil industry, meat industry to obtain proteins, peptides or amino acids, fish and crustaceans for protein chitin and chitosan. Milk by-products, mainly whey, peptides, cheese crumbs and lactose. These by products can be utilized as ingredients in production of UFs thus transforming the food market into more productive and sustainable (Sousa, 2021). Wine industry also produces various valuable products obtained from wine lees or leftover yeast, which are utilized to produce many proteins, beta glucans, thickening agents, emulsifiers, and stabilizers as food ingredients.

There are many UFs which have been reported in literature which have been produced through the incorporation or utilization of these upcycled food ingredients or food by products. These upcycled food ingredients are safe and approved by regulatory authorities to incorporate in the production and formulation of various foods called UFs which include but are not limited to; upcycled biscuits, pasta, bread, pizza, ice cream, cheese, etc., these products are completely or partly made of upcycled food ingredients or food by-products. If the specific upcycled products and the processes used are taken into consideration and compared with conventional ingredients and processes, upcycled foods can reduce greenhouse gas emissions, improve financial viability and local employment, and preserve natural resources. It is more valuable to invest in food waste reduction strategies that aim to upcycle food by-products and feed people, rather than aiming directly at animal feed, energy recovery, composting, and incinerating, as described in the food recovery hierarchy by the US Environmental Protection Agency.

Although food upcycling is recognized as an efficient strategy for food waste management, the production and consumption of UFs depends on the acceptability and response of consumers. Consumers play a pivotal role in determining the market success of upcycled food products, which are developed as an innovative strategy to mitigate food waste and promote circular economic principles. The transition from waste valorization to widespread market adoption depends not only on technological feasibility but also on consumer acceptance and willingness to purchase such products (Coderoni & Perito, 2020). Research indicates that consumers' purchase intentions for waste-to-value foods are influenced by psychological factors such as food neophobia, food technology neophobia, and environmental consciousness or concerns, which can either facilitate or hinder engagement in circular consumption models (Coderoni & Perito, 2020). Similarly, Bhatt et al. (2021) highlight that despite the environmental benefits of upcycled foods, their market potential is largely constrained by consumers' perceptions of

quality and price sensitivity. They found that consumers exhibit greater price sensitivity for upcycled foods compared to conventional alternatives, reflecting underlying skepticism toward food made from surplus ingredients. Effective communication strategies are therefore essential to bridge this perception gap and enhance consumer trust. Aschemann-Witzel (2022) further emphasizes that the way upcycled foods are communicated such as through framing emphasizing frugality, sustainability, or resourcefulness, strongly shapes consumers' attitudes and behavioral responses. Collectively, these findings underscore that consumers are not passive recipients but active gatekeepers in the diffusion of upcycled foods, and their acceptance is critical to achieving both environmental and economic sustainability in the agri- food sector. Therefore, it is very important to do the consumer analysis or evaluation of consumer responses for these types of innovative foods because these are new foods and require consumer awareness, knowledge and experience of quality and taste to develop some responses towards these foods in the form of attitudes or perceptions, purchase intentions or willingness to buy, willingness to pay, consumer acceptability and sensory evaluation.

Upcycled foods are new and innovative foods therefore consumers might show resistance or phobia like other new foods in the market, this psychological hindrance of consuming the unknown foods is called the food neophobia which is one of the most significant hurdle in the success or acceptance of new foods in the market (Coderoni and Perito 2020; Cattaneo et al, 2019; Tunca et al; 2024). Most importantly, this research on consumer evaluation was conducted in Italian consumers so in this context it becomes more critical in terms of Italian consumers, because they are well known for their culture, traditions and their adherence to the traditional eating habits. It is already

proven in the literature that food neophobia affects the attitudes and intentions of consumers towards consumption of novel or strange foods. It can either affect the attitudes and intentions of consumers directly or can moderate the relationship between perceptions and buying intentions of consumers (Tunca et al 2024; Cattaneo et al 2019; Kim et al 2024). Therefore, in this thesis the role of food neophobia was assessed for the acceptance of upcycled foods, by applying the food neophobia scale (FNS) which consists of 6 items or questions developed by psychologists and consumer behavior experts. Based on this discussion the first research question of this thesis is:

What are the consumer responses towards upcycled foods?

In addition to that there could be some factors which might affect consumer responses towards upcycled foods. To promote their consumption, it is important to understand which are the individual levers and barriers that affect the formation of consumer attitudes or intentions to buy and consume UFs. The scientific literature on other 'green foods' has already investigated several factors that promote and hinder their consumption, such as in the case of organic (Singh and Verma, 2017), biodynamic (Troiano et al. 2020) and sustainable products (Bahraseman et al. 2025), several factors have been investigated which affect the consumer attitudes or intentions towards these specific foods. To some extent, some authors also analyzed some of these factors in relation to UFs (Hellali and Korai, 2023; Grasso et al. 2023). However, so far, only a few factors at a time have been considered, and a broader picture is still missing, especially for the upcycled foods which are innovative, involve more food technologies and are different from regular foods. Therefore, the second research question of the thesis is:

What are the factors affecting consumer acceptability towards upcycled foods?

Consumer attitudes and intentions are very important part of their buying behavior, according to Ajzen (1971) this process starts with general perceptions or attitudes which develops some positive or negative or positive intentions in consumers to buy that product or not. These intentions are also called purchase intention or willingness to buy that product, and these intentions lead to the development of a particular and constant buying behavior in the consumers. There are several direct and indirect actors which are connected with the attitudes like perceived behavior control and social norms which also act on the intentions. Moreover, the consumers' attitudes and their purchase intentions may differ; they might have positive attitudes, but their purchase intentions might be

opposite, as has been found in the case of other green and innovative foods. People may have some positive attitudes or perceptions about these types of innovative foods, but when it comes to knowing their buying intentions or consuming these foods their intentions decline. This is called a green gap which is already discovered in the case of green or sustainable foods. Upcycled foods are also innovative and intended to reduce the negative impact on the environment just like green foods. But in the literature, there is no study found to evaluate this attitude intention gap particularly for upcycled foods. Therefore, it is expected that a gap exists between attitude and intention of consumers for upcycled foods. In addition to there could be several other extrinsic factors like food neophobia, health and environmental concerns affecting the attitudes or the people. Additionally, the application of a well-established behavioral model or behavioral theory in determining the attitude and intention for upcycled foods has not been implemented and not found in literature for upcycled foods. Therefore the 3rd research question of this thesis is:

What are the attitudes and intentions of consumers towards upcycled foods and is there a gap existing between attitude and intention of consumers towards upcycled foods?

To answer these research questions this thesis is structured into introduction, objectives methodology, results and discussion. At the end the conclusion of this research and recommendations are described in detail. Based on the research questions the main objectives of this thesis are the following:

- To know the consumer responses towards upcycled foods;
- To identify and assess the factors affecting the consumer acceptability of upcycled foods;
- To determine attitude and intention and assess the attitude-intention gap in consumers towards upcycled foods.

To achieve these objectives of this thesis, the research work is conducted in Italy, the study sample was based on Italian consumers because this study was funded by an Italian project “Interconnected Nord-Est Innovative Ecosystem” (INEST). This is a vast project which covers mainly the Veneto, Trentino Alto Adige and Friuli Venezia Giulia regions in Italy focusing on nine spokes areas; 1) ecosystem for mountain areas, 2) health food and lifestyle 3), green and digital transition for advanced manufacturing technology, 4) city architecture and sustainable design, 5) smart and sustainable environments, 6) tourism culture and creative industries, 7) smart agri-food, 8) maritime, marine and inland water technologies, 9) models, methods and computing technologies for digital twins. Out of these vast spoke areas the current research is related to spoke 7; smart

agri-food and research theme 3.3 titled with “circular economy in food marketing and consumer evaluation in Italy.

Apart from that there are several reasons on the basis of which this research work is conducted in Italy; firstly, there are very less studies conducted in Italy to evaluate the consumer attitudes or intentions of consumers towards upcycled foods especially, by applying any well- established behavioral model like Theory of planned behavior (TPB). Secondly, the green gap found in attitude and intention of consumers towards other green, organic or functional foods has not been studied for upcycled food in Italy. Thirdly, the Italian consumers are found to be very traditional oriented, and they intend to prefer local and traditionally produced foods. The upcycled foods are innovative, different from traditional foods, therefor, this is the most relevant and appropriate requirement of literature to find the attitudes and intentions of Italian consumers.

Hence, the structure of this thesis and the scale of analysis are outlined in table 1. It clearly indicates the different parts of the thesis in which each objective is addressed.

Table 1 Objectives and respective chapters with Scale of Analysis and place of study

Objective	Chapter / section	Scale of analysis	Country/ place
1. To identify or know the consumer responses toward upcycled foods	3	Literature review/ multinational	Worldwide
2. To identify or assess the factors affecting the consumer acceptability of upcycled foods	3	Meta-analysis analysis	Worldwide
3. To determine attitude, intention and assess the attitude-intention gap in consumers for upcycled foods	3	Survey/ consumer analysis	Italy

This thesis is structured into some chapters including the i) introduction, ii) methodology, results (3 papers published attached and one paper is under review), discussion and conclusion. Some parts of the thesis are original work and explained in the respective chapters.

Chapter 2 is developed to briefly explain the methodology of the research work including the methods used for data extraction and meta-analysis, data collection and analysis and pilot study.

Chapter 3 includes all the articles published in different journals and one meta-analysis paper which is under review. The first and second papers; descriptive review (conference paper) and systematic literature review (published) address the 1st objective of this thesis. This comprehensive review is intended to assess and explain different types of consumers responses towards upcycled foods. The third paper related to a meta-analysis paper which is under review, is developed to address the second objective of the thesis, to assess the factor affecting the consumer acceptability of upcycled foods. The fourth paper is a research paper (published) related to the 3rd objective of the thesis. This paper explains the results of survey-based research conducted in Italy and elaborated in detail with the help of a behavioral model, the factors affecting the Italian consumers attitude and intention and the gap between them for upcycled foods.

Chapter 4: This chapter is about the discussions and conclusion of the overall results in detail, and evidence are collected from different analyses and integrated results are discussed and elaborated. The conclusion part of the whole research work is where all the activities, methodologies, and important findings are concluded. It also entails the limitations of this research work and also the further research opportunities in this area of research.

2 CHAPTER II: MATERIAL AND METHODS

This chapter provides an overview of the methodology adopted to achieve all the objectives of the thesis. In this section the methodology adopted for each objective will be briefly discussed and it will be elaborated in the respective sections in detail. The subjects of this chapter are divided according to the objectives of the thesis and Table 2 provides a brief summary of each method adopted in different sections respective to each objective.

Table: 2. Methodology used to achieve stated objectives by section/chapters

Chapter/section	Research output	Objective	Methodology	Methodology section
Chapter 3	Published	1	Descriptive and Comprehensive literature review	2.1 Literature search
Chapter 3	Under Review	2	Meta-analysis	2.2 Data extraction and meta-analysis
Chapter 3	Published	3	Consumer survey in Italy	2.3 Data collection and data analysis 2.4 Pilot Study

2.1 Literature Search

According to the first objective of the thesis, to know the consumer responses towards upcycled foods a comprehensive literature search was conducted.

However, upon reviewing the literature, until 2023, as this research work was started in 2023 based on the project INEST, there are no such systematic literature review reported on the consumer evaluation of upcycled foods to extract the data on consumer responses towards upcycled foods systematically or by adopting a predefined and registered protocol. However, there are only three reviews papers and one commentary review found in literature; the first one was published in 2021 by Aschemann-Witzel and Stangherlin (2021) in which they described individual, contextual and

product related factors as determinants of acceptability of waste to value foods in the market. The second descriptive review discussed the development of a comprehensive definition of upcycled foods, inclusion of upcycled foods in food waste management hierarchy and described the sociodemographic and beliefs as determining factors of upcycled foods acceptability (Moshtaghian et al., 2021). The third descriptive review described the two fold definition of upcycled foods; avoiding food waste and giving a sense of novelty, to better frame consumer perceptions about them. Finally, the commentary review published in 2023 highlighted four main points; consumer product evaluation, consumer identities, consumption occasions and word of mouth (WOM) as opportunities for the growth of UFs (Ye et al 2023). Moreover, investigating the overall consumer responses towards UFs from beginning in the form of perceptions to willingness to buy and pay till their consumption experience is missing in literature through systematic literature review.

Based on these facts firstly a descriptive literature review was conducted from different databases, and a short literature review paper was published in an international conference Journal. Secondly, a systematic literature was extracted from Scopus database by using specific and unique string of words which covered all the relevant and most appropriate terms related to upcycled foods, circular economy and consumers. The string of words is as follows;

Food AND Consumer AND (“circular economy” OR upcycl OR recycl* OR reprocess* OR “waste to value” OR “value added surplus” OR “rescue based”)*

The target population of studies included those evaluating consumer responses to UF products; perceptions or attitudes, willingness to buy or purchase intentions, UF acceptability, willingness to pay and sensory evaluation or after purchase experience by consumers. The studies describing the sensory evaluations by trained judges or sensory panelists and the surplus or leftover foods in restaurants or hotels were excluded as they did not fulfil the criteria of general consumers and upcycled foods respectively. The studies evaluating all types of consumers without distinguishing the students, professionals, households, etc. and all types of studies i.e. surveys, experiments, auctions and field studies were included. The search was limited to the Scopus bibliographic database, given its comprehensive coverage of peer-reviewed scientific literature. To ensure the relevance and quality of the review, we applied the following inclusion and exclusion criteria:

- i. Only peer-reviewed scientific articles were included, to ensure robust, validated results.
- ii. Articles were limited to those written in English, focusing on internationally accessible research.

iii. Publications before 2010 were excluded to focus on recent evidence, as earlier material on this topic is scarce.

The results obtained through this initial search were subjected to a comprehensive screening based on a predefined inclusion and exclusion criteria. For this purpose, a PRISMA (Preferred Reporting Items for Systematic review and Meta-Analysis) protocol was followed, and the total number of studies finalized at the end included in the analysis. After careful finalization, relevant data was extracted from the reported research papers which included:

- Author name
- Title
- Year of publication
- Country of publication
- Type of consumer response studied (attitude, willingness to buy/ purchase intention, willingness to pay etc.)
- Response type evaluated in the study (positive, negative, neutral)

After careful extraction, the retrieved information was arranged in a tabular form, and all the responses were evaluated with the help of Total Food Quality Model (TQM). It was elaborated how consumer responses evolve from initial perceptions through consumer characteristics, product characteristics, intrinsic or extrinsic cues, cost cues, and experienced quality.

2.2 Data extraction and Meta-analysis

Based on the second objective of the thesis we used the research papers obtained from the extensive literature search and by applying the PRISMA protocol and extracting some more relevant and required data to address my second objective my thesis.

This meta-analysis step was conducted because there is no prior meta-analysis on the consumer analysis of upcycled foods exist in literature. However, meta-analyses have been carried out on sustainable, eco labeled or green foods. For example, Bastounis et al., (2021) conducted a meta-analysis on willingness to pay (WTP) for eco-labeled foods, while Cheng et al. (2024) performed a meta-analysis showing that consumer environmental perceptions of green foods increased their acceptability. However, unusual responses from consumers may occur due to the hypothetical or non- hypothetical nature of the studies (Li and Kallas, 2021)

In conclusion, these individual meta-analysis studies focused on various other sustainable, organic or green foods, yielding varying results. Nevertheless, a comprehensive meta-analytical picture examining the role of different factors in determining the acceptability of upcycled foods is

still missing from the literature. The present meta-analysis is the first of its kind to quantitatively analyse the effect of three distinct aspects on the acceptability of upcycled foods: (i) consumer perceptions and attitudes towards upcycled foods; (ii) upcycled food characteristics or extrinsic cues related to upcycled foods; and (iii) communications or information provided to consumers about upcycled foods.

Based on this objective we collected only those research papers out of all the literature review, in which regression analysis was conducted to analyze the effect of different factors like perceptions, product characteristics, and information of communication on consumer acceptability of upcycled foods was determined. The three main factors which have been identified through literature and various studies are consumer perceptions, product characteristics and communications or information about the upcycled foods. So, during the data extraction only those studies were finalized in which the effect of these types of factors on consumer responses was analyzed through regression analysis. The values of regression coefficients, p value, standard error and confidence intervals (C.I) were extracted from the finalized research papers and collected and arranged in Microsoft excel sheet.

Data was analyzed in r software by using *metaphor* package and by applying random effect model (REM) and restricted maximum likelihood (REML) estimator. The results were displayed by funnel plot and forest plot to display the publication biasness and dispersion of effect sized across the studies respectively.

2.3 Data collection and analysis

To achieve the third objective of the thesis we conducted an online survey on Italian consumers. We developed a questionnaire containing 48 questions divided into several parts. The first part of the questionnaire contained a brief introduction about the upcycled foods and about the purpose of the survey so that the respondents may know about the type of information we were intended to get from them, they were also asked about the consent agreement questions that the respondent willingness or voluntary participation in the survey may be guaranteed. The data privacy assurance was also guaranteed during this survey and subsequently, 48 questions were asked related to the following information. The question items are given in Appendix B of chapter 4.

- Food neophobia (FN)

- Health consciousness (HC)
- Environmental concerns (EC)
- Traditionality (TD)
- Attitude (AT)
- Intention (INT)
- Subjective knowledge (SK)
- Social norms (SN)
- Behavioral control (BC)

A theoretical model was developed by following the theory of planned behavior (TPB) (Ajzen, 1991) to analyze the effect of above-mentioned factors on attitude and intention. This theoretical model constitutes Intention, attitude, social norms and behavioral control as core elements of the model, being one of the most common theories in behavioural economics. This has been used on a variety of products, from organic (Chen, 2007, 2009), to insect- based (Bae and Choi, 2021), to genetically modified foods (Kim *et al.*, 2014). Moreover, in literature this theoretical model is not being used for the determination of attitude and intentions of consumers towards upcycled foods. Therefore this theoretical model is adopted in this research. According to TPB, attitudes, social norms and behavioural control directly affect the individual behavioural intention. The other all components of the model were added according to the other studies in which food neophobia, subjective knowledge, health consciousness and environmental concerns. The effect of food neophobia was determined on both attitude and intention in two different ways. To analyze data, covariance-based structural equation modelling (CB-SEM) was used (Zhang *et al.*, 2021) in R software using the lavaan package.

2.4 Pilot Study

Before starting the main survey, a pilot study was conducted on the students at University of Padua Italy. During this initial survey total 52 responses were collected and the validity and consistency of the constructs of the model was determined. The sociodemographic analysis of the respondents was also conducted to see that the respondents from all over the Italy took part in the survey. The consistency and the validity of the constructs was determined by using Cronbach alpha (α) and average variance extracted (AVE), in addition to that the discernment validity was determined by using the square root of average variance extracted (AVE) which is called the

Fornel-Larker Values (FLV). Rest of the methodology and results are discussed in respective sections in detail.

3 CHAPTER III - RESEARCH PAPERS

The three papers included in this PhD program will be presented in the next pages.

3.1 PAPER 1



Systematic Review

Upcycled Foods: What Influences Consumer Responses to a Circular Economy-Based Consumption Strategy? Insights from a Systematic Literature Review

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Abstract

Upcycled foods (UFs) are foods that are produced from ingredients that would otherwise be wasted and are considered a sustainable solution to the issue of food waste. However, since consumers' responses to these foods will ultimately determine their success, there is a need to identify the factors that affect such responses. This systematic review is intended to contribute to fulfilling this need. A literature search was conducted on Scopus on 10 July 2025. Following the PRISMA protocol and setting selected inclusion criteria (scientific papers on consumer evaluation of UFs published since 2010 in English), 54 research articles (83 studies) were analyzed. The findings are discussed through the lens of the Total Food Quality model, where product cues, combined with consumers' characteristics and perceptions, develop consumers' ultimate responses, such as general attitude (analyzed in 91.7% of the reviewed studies), purchase intention (77.4%), sensory evaluation (69.2%), and willingness to pay (66.7%). Despite the general positive consumer attitudes toward UFs, translation into actual purchasing behavior is not immediate, and consumer awareness appears to be a major obstacle. However, the analysis of the literature suggests promising strategies to widen the acceptance and consumption of UFs. These entail the use, for example, of informational tools (e.g., claims and certifications), which can be differentiated to target consumers with different levels of knowledge and appreciation of UFs. In addition, targeting specific consumer segments (e.g., environmentalists) can promote a faster acceptance and spread of UFs, while providing

information about the nature of UFs will likely help to reduce relevant barriers, such as price sensitivity, risk aversion, and food and technology neophobia.

Keywords: upcycled foods; food waste; circular economy; consumer preferences; consumption

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1. Introduction

Sustainability in food production and consumption, as originally defined, refers to a systemic approach that meets current environmental needs without compromising the ability of food processes to complete their natural cycle [1,2]. This concept holds significant importance in the food and agricultural sector, particularly concerning the United Nations' Sustainable Development Goals (SDGs) [3–5]. SDG2 aims to achieve zero hunger by 2030, while SDG12 promotes sustainable production and consumption patterns [6]. Moreover, ensuring food security, defined as the provision of sustainable and nutritious diets to individuals and communities, remains a critical challenge of our time [7].

The anticipated challenges in delivering sustainable, healthy, and sufficient food are expected to intensify as the global population is projected to reach approximately 9 billion by 2050 [8]. From this perspective, food waste represents a significant global challenge for sustainable food production and consumption. Approximately one-third of the total food produced for human consumption is wasted or lost annually, leading to adverse consequences such as food insecurity, financial losses, and environmental degradation [9–12].

The annual global estimate of food waste is around 1.3 billion tons, occurring at various stages in the food supply chain, including production, storage, processing, distribution, retail, food service, and final consumption [13–16]. In addition to entail a cost of approximately USD 990 billion annually [17], this waste also contributes to 8–10% global greenhouse gas emissions [18]. In Europe, according to Eurostat, around 59 million tons of food waste are generated every year, with the highest share occurring at the household level (around 32 million tons) [19]. Therefore, mitigating food loss and waste stands out as a pivotal objective for attaining a sustainable food system [20].

To address this challenge, the valorization of food by-products has emerged as a potentially valuable approach, focusing on reusing, recycling, or upcycling food by-products that would otherwise be wasted during food manufacturing and processing [21–23]. Food waste valorization has been shown to produce positive environmental, economic, and social advantages [24].

The practices of food by-product valorization can be included under the broader umbrella of the circular economy. This concept is meant to be an alternative to the classic linear model characterized by the consecutive chain of production–consumption–disposal. By introducing concepts such as reusing, repairing, recycling, or reprocessing, by-product materials and leftover products can re-enter the production cycle [25].

The adoption of these concepts led to the implementation of several food production processes that can use a wide variety of food wastes, some examples being brewery or coffee spent grains [26,27], hazelnut residues [28], olive oil pomace [29], or by-products of the wine industry [30–32]. Foods that incorporate food residues and by-products as ingredients are called upcycled foods (UFs). Specifically, the Upcycled Food Association gives the following definition of UFs: “Upcycled foods use ingredients that otherwise would not have gone to human consumption, are procured and produced using verifiable supply chains, and have a positive impact on the environment” [33] (p. 2).

As a result, multiple upcycled products for human consumption have appeared, from biscuits made with grape pomace [34] to muffins made with banana residues [26] or upcycled chicken nuggets and ice creams [35].

However, a relevant question is how these products will perform on the market. Here, consumers play a major role, and their acceptance of these innovative products is crucial for the establishment of a relevant UF market. Specifically, two questions are of particular interest:

- a. *What is the response of consumers toward these products?*

Understanding whether consumers have a favorable opinion of this novel food category and whether they will introduce UFs into their diets will allow us to gauge the current potential of the UF market.

- b. *Which factors shape consumers’ opinions and decisions about UFs?*

Answering this question will help identify possible ways to promote and spread their consumption as a means to lower the environmental impact of food chains.

These two questions constitute the research questions of our work. As the literature has already extensively investigated, albeit at different levels, the relationship that consumers have with UF products, a systematic literature review appears to be the best strategy to summarize the scattered evidence collected by other authors and attempt to condense them to answer our two research questions. In this respect, some efforts have already been made in this direction. Swaraj et al. [36], for example, in reviewing potential barriers to the development of the UF sector, identify some consumer elements that may hinder such development. In this respect, our exclusive focus on consumer

allows for a more thorough investigation of the relationship of consumers with UFs, not just through a “barrier” perspective, but also by analyzing factors potentially prompting positive responses. A similar approach was adopted by Moshtaghian et al. [37] (who, however, did not adopt a systematic approach) and Aschemann-Witzel and Stangherlin [2] in their reviews on UF consumption. Our contribution adds to these works in two ways. First, we extend the period of analysis, which, in a rapidly growing literature sector, allows us to add a relevant amount of new evidence. Second, in contrast to their ex-post, inductive syntheses of re-viewed studies, we synthesize the literature using a pre-determined theoretical framework. This allows us to better connect the collected evidence to consumption theory, thus possibly deriving more insightful conclusions.

Indeed, to guide our inquiry, we ground the review in the Total Food Quality (TFQ) model [38], a framework often used in consumer studies to describe the formation of consumers' intentions. The choice of this theoretical framework, which is explained in detail in Section 3, was guided by its comprehensiveness. Most consumer acceptance frameworks tend to place their main focus either on product characteristics (e.g., cue utilization theory [39], Lancaster demand theory [40]) or on consumer characteristics (as in behavioral models of consumption, such as the Theory of Planned Behavior [41] or the Norm Activation Model [42]). Conversely, the TFQ model considers both product attributes as well as their perception by consumers, thus recognizing the role played by both product and consumer characteristics in product evaluation. In addition, the TFQ model takes into account both ‘before purchase’ and ‘after purchase’ factors that might affect consumer evaluations, with the aim of providing a more comprehensive overview of the consumption dynamics. In our view, such a level of comprehensiveness allows us to more thoroughly synthesize the evidence obtained from the literature.

The methodology used to conduct the systematic review is illustrated in the next section. In the following section, we report the results. Finally, a discussion and a conclusive section summarize the main evidence collected from the revised literature, offering relevant reflections and potential suggestions for the future development of the UF sector, at least with respect to demand-related aspects.

2. Materials and Methods

To address our research questions, we conducted a systematic literature review. Following Stiletto et al. [43], we integrated the three-step approach proposed by

Tranfield et al. [44]- planning, conducting, and reporting the review- with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) reporting guidelines from Page et al. [45] (no protocol was registered). The first step, planning the review, involved clearly defining our research questions:

RQ1: *What is the response of consumers toward UF products?*

RQ2: *Which factors affect the response of consumers toward UF products?*

In this context, we define “response” as a broad spectrum of consumer reactions, which range from consumer perceptions to actual purchasing behaviors. This definition, as illustrated later, served to clearly define one of the eligibility criteria to be used in the retrieved studies. This comprehensive approach aligns with the scope of consumer economics, which extends beyond final purchasing patterns to include the analysis of preferences and motivations underlying consumption choices. Furthermore, this broad definition allows us to examine whether UFs elicit different responses depending on the type of evaluation, potentially revealing that positive perceptions do not necessarily translate into positive purchasing behaviors.

Our target population of studies included those evaluating consumer responses to UF products. We limited our inquiry to research listed in the Scopus bibliographic database. Although this must be considered a limitation of our study, Scopus has been recognized as being wider in scientific coverage than other bibliographic databases [46]. In addition, the usually mentioned

limitations of Scopus, like worse coverage of old research [47] and limited availability of books and conference proceedings [48], were not relevant for this task. Indeed, to ensure the relevance and quality of our review, we applied the following inclusion and exclusion criteria:

- i. Only peer-reviewed scientific articles were included to ensure robust, validated results.
- ii. Articles were limited to those written in English, focusing on internationally accessible research.
- iii. Publications before 2010 were excluded to focus on recent evidence, as earlier material on this topic is scarce.

The second step of the approach by Tranfield et al. [44] in conducting their review involved creating and implementing a search strategy. Based on our research questions, we developed the following search string:

TITLE-ABS-KEY (food AND consumer AND (“circular economy” OR upcycl OR re- cycl* OR reprocess* OR “waste to value” OR “value added surplus” OR “rescue based”))*

To keep the initial search wide enough not to miss relevant research, we included, in the search string, terms that are sometimes used as synonyms of “upcycled” (“reprocessed”, “recycled”, “rescued”) [49]. In addition, some terms are used in the literature to indicate specific concepts that, given the broad scope of the definition of UFs (see Section 1), can be grouped with “upcycled”. That was the case for “waste-to-value foods”, which entails the “reuse of waste and by-products to increase the nutritional power of food or its shelf-life extension” [50] (p. 2), and “value-added surplus products”, which are defined as “foods made from surplus ingredients that would have been otherwise wasted” [49] (p. 57).

This initial search was conducted in 2023 but it was revised on 10 July 2025 and the duration of search was kept until 2023 because this research work was started in 2023 based on the iNEST project. The outcome provided 2514 bibliographic entries. Applying the filters corresponding to our inclusion and exclusion criteria (document type = “Article”; language = “English”; Year = 2010–2023) returned 1442 documents. As per the PRISMA flow diagram (Figure 1), this constitutes the identification phase of our systematic review process.

The screening phase involved a systematic evaluation of bibliographic entries by one of the researchers, conducted in three consecutive stages: initial screening based on titles, followed by abstract review, and concluding with full-text assessment.

The following screening criteria were used:

- i. The products considered are UFs, according to the definition provided by the Upcycled Food Association (see Section 1).
 - ii. The study deals with consumers, with no restriction on consumer type. Studies involving only expert panel evaluation were excluded.
 - iii. The study investigates consumer responses to UFs, where “responses” can include attitudes and perceptions, acceptability, purchase intention and willingness to buy (WTB), willingness to pay (WTP), sensory evaluation, and actual purchase. Papers investigating multiple responses were split into separate studies.
 - iv. All study designs were eligible, while purely methodological works were discarded.
- The screening process resulted in the selection of 54 articles for inclusion in our review.

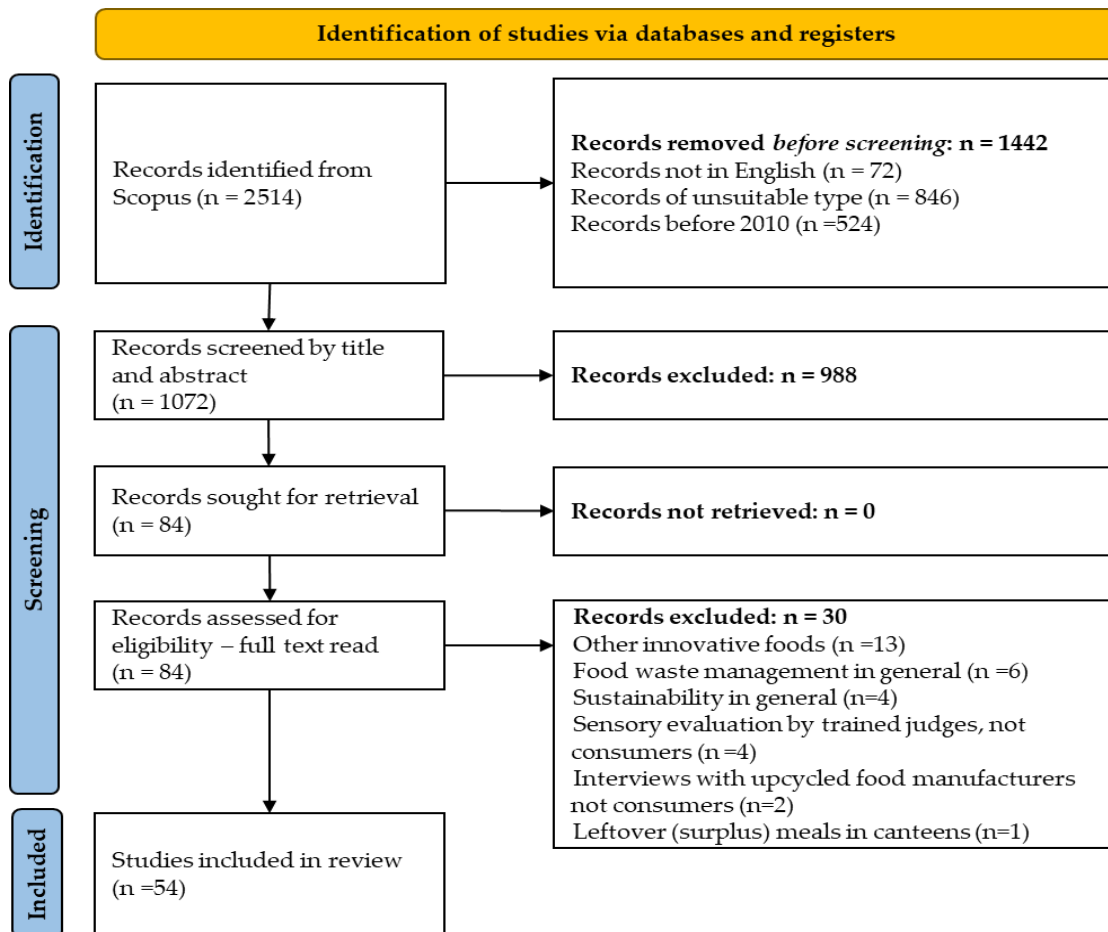


Figure 1. Literature retrieval and selection based on the PRISMA flow diagram.

The third step involves reporting the results. In this section, we present the bibliometric characteristics of the included material, while a detailed analysis of the content follows in the subsequent section of the manuscript. Specifically, the analysis of the content required the collection of information from each included study on two classes of elements: (i) consumer response to UFs; (ii) factors that affect consumer responses. For both classes, a vote-counting approach by direction of the effect was adopted. For the first class, we counted the number of studies with different consumer response directions (negative, null, or positive). For the second class, we counted, for each analyzed factor, the number of studies with different effect directions of the factor on the consumer response. The factors in the latter class were further categorized into (i) product cues; (ii) consumer characteristics; (iii) consumer perceptions; and (iv) experienced quality. This classification, as explained in Section 3, was based on a theoretical model of consumer behavior (the Total Food Quality model), which served as a framework to synthesize and report the review results. The collection of data from the reviewed studies was initially performed by one of the authors, while a validation of all analyzed records was performed by a different one.

A temporal analysis of the selected literature (Figure 2) reveals that, within our defined time period, no paper was published before 2018. This observation underscores that the study of consumer preferences for UFs is an emerging field of research. Despite its nascent status, the topic has garnered significant attention in recent years, as evidenced by a notable increase in publications, particularly in the last few years.

Analysis of publication venues (Figure 3) reveals that *Food Quality and Preference* is the leading journal in publishing studies on consumer evaluations of UF products. However, beyond this primary source, the publication landscape appears notably diverse, with articles on the topic dispersed across a wide array of journals. This fragmentation might be attributed to the absence of specialized journals dedicated to UF products or to the lack of established research strands within existing journals.

Finally, an analysis of the geographical distribution of the articles (Figure 4) reveals significant disparities across different regions. European countries dominate the landscape, followed by North America and Oceania. In contrast, Latin America and Africa are notably underrepresented in literature. At the country level, Italy and the US display the highest number of studies (11 articles), followed by the UK (5 articles) and Canada, New Zealand, and Denmark (4 articles each).

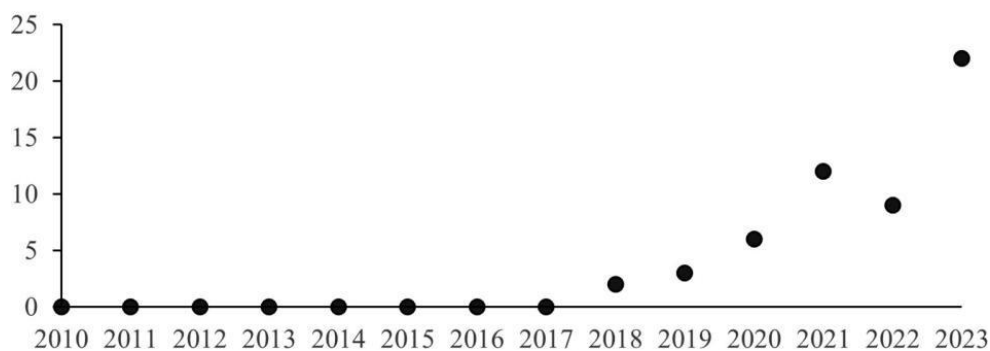


Figure 2. Number of publications per year (2010–2023).

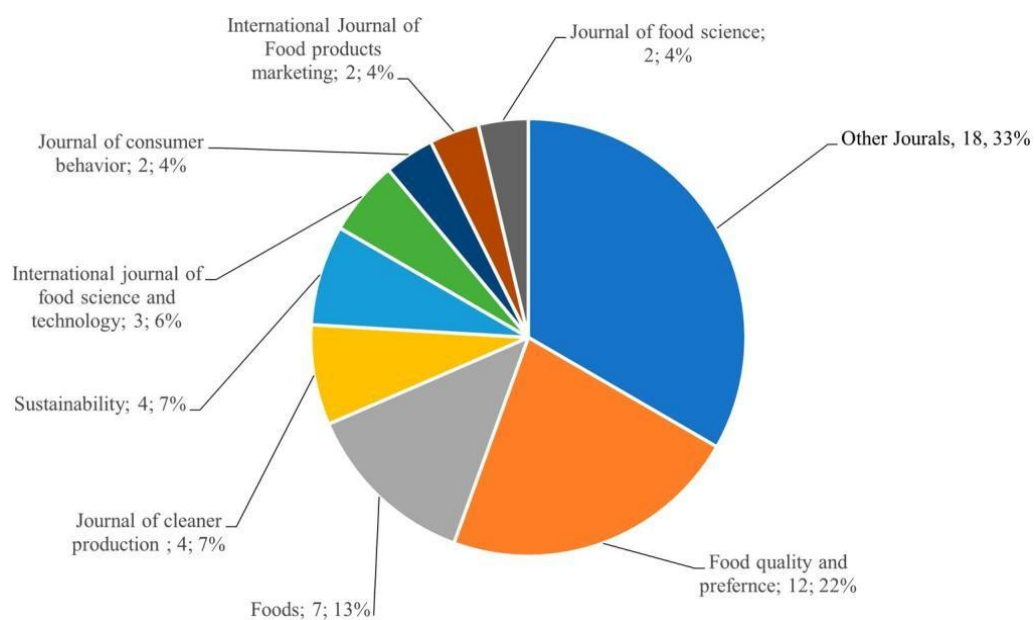


Figure 3. Number of papers published in different scientific journals.

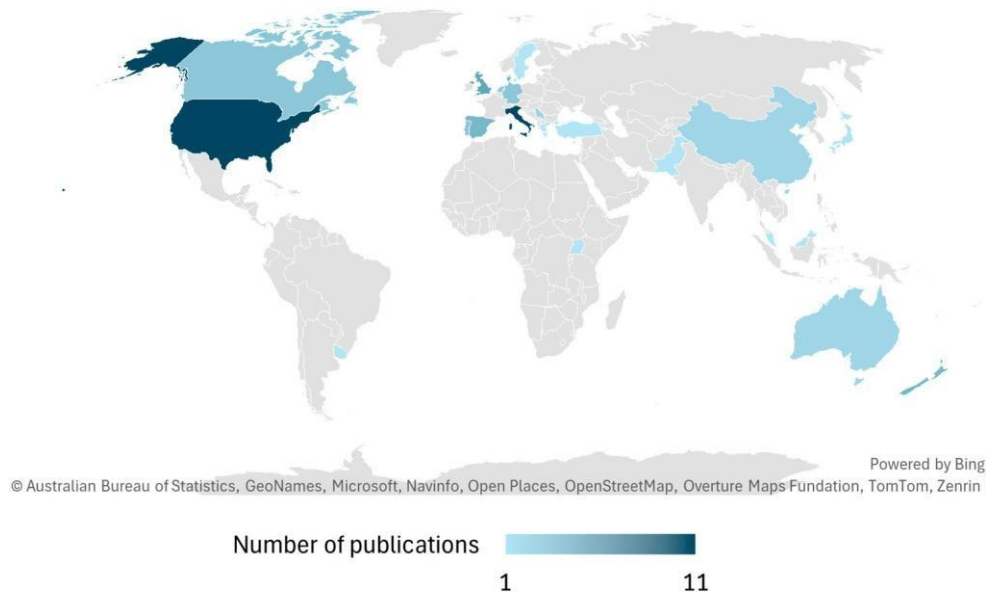


Figure 4. Number of articles published in different countries.

3. Results

To synthesize the retrieved literature, we employed an adapted version of the Total Food Quality model proposed by Grunert et al. [38] (Figure 5). Specifically, we kept the original two-dimensional structure. The horizontal dimension distinguishes between before-purchase expectations and after-purchase experience. The vertical dimension addresses the inference-making process through which consumers utilize a set of signals to form expectations (before purchase) or evaluations (after purchase) of product quality, ultimately leading to a specific response.

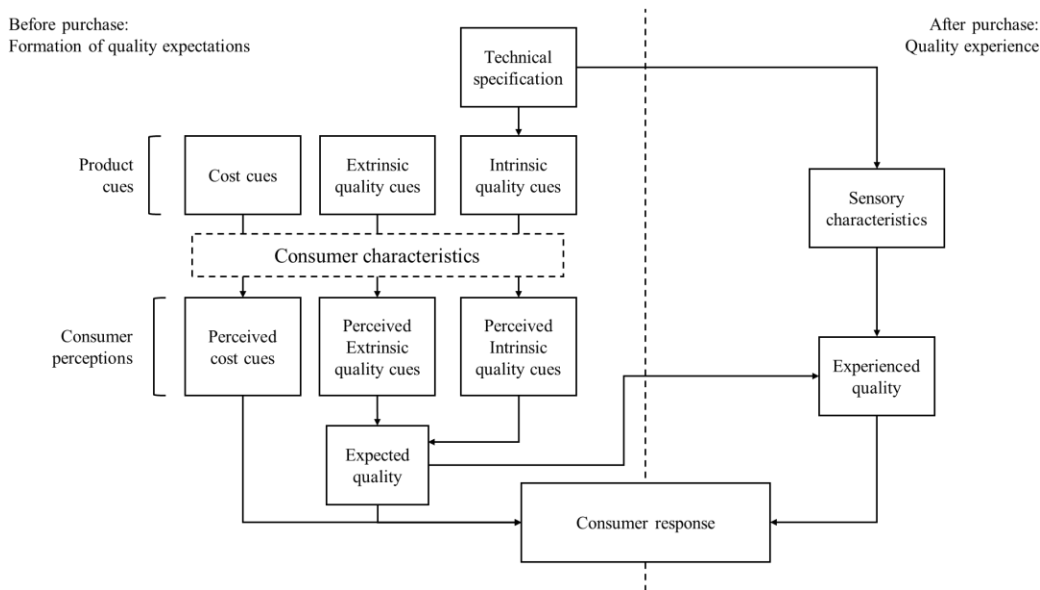


Figure 5. Modified version of the Total Food Quality model used as a theoretical framework.

Most of the constructs of the original model, as well as the connections between them, were also maintained. However, we decided to remove four constructs and merge two others. With respect to the latter, while the original TFQ model distinguishes between a before- purchase and an after-purchase type of response (respectively, *intention to buy* and *future purchases*), we merged the two into a *consumer response* construct. This allowed us, on the one hand, to accommodate a larger set of consumer responses not limited to purchase intentions, in line with the objectives of the review. On the other hand, in scientific studies, *experienced quality* is usually operationalized, especially for novel product categories, using experimental tastings. This means that what is commonly measured is still often a pre- purchase response, as consumers never really bought the product.

With respect to removed constructs, two of them relate to the pre-purchase stage. Here, we dropped the *perceived costs* (which in the original model mediate the relation between the *perceived cost cues* and the *intention to buy*) and the *expected purchase motive fulfillment* constructs (which is the mediator of a further indirect effect of *expected quality* on *intention to buy*). In the after-purchase stage, we removed *meal preparation* and *experienced purchase motive fulfillment*. The former, which represents the way in which consumers decide to prepare food at home, is affected by the *perceived intrinsic quality cues* and the *expected quality*, and in turn affects the *experienced quality*. The latter plays a similar role in the *expected purchase motive fulfillment*, mediating the effect of *expected quality* on *future purchases*.

The decision to remove the four constructs was made to keep the model simple, in light of the objectives of the review. *Perceived costs* could be, in fact, conveniently integrated into the

perceived cost cues, at least for the costs directly connected to UFs, which were the ones of interest. *Meal preparation* is a construct of a rather technical nature, which falls beyond the scope of this review. *Purchase motive fulfillment* (*expected* and *experienced*), in addition to not being investigated for UFs by researchers (as ex-post evidence), was likely related to more general consumption motives, and not intimately related to UF.

Finally, we added to the original model an additional construct, *consumer characteristics*, as a moderator between the *product cues* category and the *consumer perceptions* category. Indeed, several behavioral models, e.g., the Theory of Reasoned Actions [51], Norm Activation Model [42], and Theory of Planned Behavior [41], posit that an individual's perception of a product is significantly influenced by their personal characteristics, including socio-demographics, attitudes, interests, and intrinsic values.

The presentation of the results below is therefore arranged according to four classes, inline with the revised TFQ model structure: *product cues*, *consumer characteristics*, *consumer perceptions*, and *sensory characteristics*. The coding used is reported in Table A1 in Appendix A.

3.1 Consumer Responses

While the original TFQ model focuses on the intention to purchase (or repurchase) a specific food product, our review adopts a broader perspective, considering a more comprehensive *consumer response* category. This decision was taken considering that purchase intention is just one of several ways to investigate consumer preferences for food products, which can be assessed through multiple indicators. Before delving into the effect of various factors on consumer responses, it is crucial to understand how literature evaluates consumer preferences for UF products and what the outcomes of these assessments are.

The main indicators used to assess consumer responses towards UFs are purchase intention or WTB (37.35%), consumer acceptability (18.07%), WTP and general perceptions (14.46% each), and sensory evaluation (15.66%) (Table 1). Purchase intention or WTB is basically the intention to purchase or buy UFs. Consumer acceptability is the degree to which consumers are open to accepting, trying, and including UFs in their diets. WTP is the intention or willingness of consumers to pay a price premium for UFs. General perceptions are the attitudes that consumers have about UFs, which may not necessarily translate into actual intention or behavior. Finally, sensory evaluation includes the actual experience of UFs based on sensory parameters such as smell, aroma, texture, and taste.

Table 1. Number of studies analyzing different types of consumer responses towards UFs (percentages in parentheses).

Parameter/Response	Total Articles ¹	Total studies ¹	Positive results	Negative results	Null results
General perceptions	9 (16.66%))	12 (14.46%)	11 (91.67%)	1 (8.33%)	0 (0.0%)
Consumer acceptability	10 (18.51%))	15 (18.07%)	12 (80.0%)	2 (13.33%)	1 (7.1%)
Purchase intention/ Willingness to buy	22 (40.74%))	31 (37.35%)	24 (77.42%)	7 (22.58%)	0 (0.0%)
Willingness to pay	10 (18.51%))	12 (14.46%)	8 (66.67%)	4 (33.33%)	0 (0.0%)
Sensory evaluation	13 (24.07%))	13 (15.66%)	9 (69.23%)	4 (30.77%)	0 (0.0%)
Total	54 (100%)	83 (100%)	64 (77.11%)	18 (21.69%)	1 (1.20%))

Note: By-column shares are reported for the *Total* columns, while by-row shares are reported for the other three columns (*Positive*, *Negative*, *Null*). ¹ The differences between the number of articles and the number of studies is due to the presence of articles containing multiple distinct studies. This also implies that an article can study multiple different responses, causing the sum of the articles in the first column to be different from the total number of articles. ² The sum across categories is 64 because there are some papers in which two or more than two different types of responses are studied.

Most studies (77.11%) reveal a positive inclination of consumers towards UF products, which is particularly evident when examining general perceptions [10,49,52,53]. Consumers generally view these products as environmentally beneficial, particularly in reducing food waste [54,55]. Additional positive perceptions include improved taste [54] and enhanced nutritional and food safety characteristics [10].

These positive perceptions often translate into high acceptability of UFs across diverse contexts, from olive oil by-products [56] to bread enriched with wine by-products [57], seafood by-products [58], or upcycled ingredients soups [59]. Similarly, consumers appear willing to try these products, as 77.42% of the studies identified positive WTB and purchase intentions [50,60–62]. In some

instances, purchase intention can be enhanced by specific communication strategies, such as providing rational messages [63], appropriately designed logos [64], or clearly listing the product ingredients [26]. However, some studies found that information and communication strategies are essential to stimulate purchase intention, which would otherwise be absent among consumers [65,66]. Indeed, in certain cases, as observed in New Zealand [67] and Spain [68], the presence of upcycled ingredients actually reduces the acceptability of food products.

Even more heterogeneous results are observed when investigating WTP. In this case, two-thirds of the studies found that consumers are willing to pay a price premium for UFs, primarily as a recognition of their environmental benefits [35,57,69]. However, a significant proportion of studies estimated negative price premiums, sometimes attributed by the authors to inadequate communication of the positive aspects of UFs [35] or consumer price sensitivity [70].

What emerges is a pattern where positive consumer responses, although prevalent, decrease as consumers approach actual consumption. When asked about their general attitudes, almost all studies agree on a positive perception of UF. However, when consumers are questioned about potential actual behavior (such as intention to buy or pay), heterogeneity emerges. This evidence is not unexpected, as multiple factors can influence the path from attitudes to actual behavior, as theorized in several consumption behavior models. Additionally, multiple studies have empirically observed that, especially for sustainable food products, a significant gap exists both between consumers' attitudes and intentions, as well as between intentions and behavior [71,72].

A final response investigated in the literature is product sensory evaluation. Here too, heterogeneity is relatively high, with 69.23% of the studies identifying positive results and 30.77% observing negative evaluations of UFs. In this regard, Costantini et al. [73] reported a higher overall liking for biscuits containing hazelnut skin, and similar results were observed for upcycled rice crackers [74], beef with upcycled ingredients [68], and muffins made from brewery spent grains [69]. Positive overall sensory evaluations were also noted by [75–77]. Conversely, consumers gave low scores to the sensory evaluation of cereal bars made with brewers' spent grains [78] and negatively evaluated several sensory characteristics (e.g., taste, texture, and appearance) of upcycled burgers or bread made with tomato by-products [79,80].

3.2 Product Cues

According to the *cue utilization theory*, consumers use effective cues to make decisions [63,64,81]. In the TFQ model, *product cues* are divided into intrinsic, extrinsic, and cost cues.

Intrinsic cues relate to the physical properties of the product, directly derived from its production method (*technical specification* in Figure 5), such as color, fat cover (e.g., for meat), or visible damage (e.g., for fruit). All other cues are considered extrinsic [39]. The TFQ model specifically separates cost cues, which primarily relate to price and other costs associated with obtaining the product (e.g., travel and time).

In the literature on UFs, cost cues are primarily investigated in terms of price, with several articles analyzing how the price of UFs affects consumers' acceptance and preferences. Although in some contexts and for some consumer segments, it is not uncommon for price to act as a quality signal, the reviewed studies on UFs report the usual inverse relationship between price and measures of consumers' responses [55,70,82]. For example, Ref. [26] observed that 56% of New Zealand consumers found UFs with brewers' spent grains more attractive when priced lower. Similarly, in the US, Ref. [62] showed that consumers were willing to buy by-products of fruits, vegetables, seed oils, spent grains, cereals, fish, and meat if they had a lower price. According to Stelick et al. [78], the lower optimal price point of upcycled cereal bars with brewers' spent grains was the main driving factor of their acceptability.

Interestingly, a study by Peschel et al. [83] suggests that cost transparency (i.e., acknowledging the additional costs required to produce upcycled products) can improve perceived price fairness, thus stimulating the acceptance of upcycled products.

The second type of cues we consider are extrinsic product cues. In the literature on UFs, these cues are mainly related to delivering information about desirable product characteristics, such as reduced environmental impact, beneficial nutritional and food safety effects, or their role in food waste management and the circular economy.

Regarding food safety, Moshtagian et al. [10] observed that food safety information, for example, through traceability, contributes to consumer acceptability of UFs in Sweden. In Korea, Jeon [53] observed that food safety was the main reason for selecting UFs by consumers. Similarly, in the US, the presence of safety information about seafood by-products led to higher consumer acceptability [58].

A more important extrinsic cue, however, is environmental information, which positively affects consumers' response to UFs. This is observed, for example, on the attitudes of European consumers by Aschemann Witzel et al. [84]. Similarly, Goodman-Smith et al. [54] observed that most New Zealand consumers deem upcycled beer to produce more environmental benefits, be more sustainable, and have a lower carbon footprint. This, as shown by McCarthy et al. [61] in Australia, may lead respondents to display a willingness to buy UFs due to their

perceived positive impact on the environment, or to turn perceived environmental sustainability into a WTP driver [82]. Similarly, in the US and China, consumers were more likely to try UFs as they perceived them as better for the environment [62].

Waste management is closely related to environmental. Indeed, adopting a 'recycling' perspective, the consumption of UF holds the promise of reducing food waste. Informing consumers about the nature of these foods may have positive effects on purchase behaviors. For example, Ref. [66] found that 89% of respondents were willing to buy UFs due to their association with reduced food waste, which was the highest predictor of purchase intention. Similar evidence has been obtained by Kawata and Kubota [85] and McCarthy et al. [86], where respondents' willingness to buy UFs was strongly related to their perception that the food contributed to food waste reduction. However, in some cases, knowledge of the link between UF and food waste might be counterproductive. This was observed, for example, by de Visser-Amundson et al. [59], who highlighted that explicitly associating upcycled products with food waste might reduce purchase intention or lower the WTP due to risk-averse individuals relating food to waste [87].

This potential concern opens the way to another set of cues, namely health-related ones. Information about health attributes and nutritional value can thus enhance consumers' purchase intention [65,88], their WTP [57,69,87] and their attitudes in general [62,89]. In part, this might be due to the attention to the presence of health attributes on food by some consumer segments. However, some consumers were also observed to perceive UFs as intrinsically healthier than their conventional counterparts [68,90], thus possibly reinforcing the effect of health cues on UFs. It is important to note that the reviewed literature does not investigate the objective nutritional characteristics of UFs, whose analyses lie within the scope of other research fields.

While information about the potential benefits of UFs can be conveyed through claims, official logos and certifications are alternative information tools that can be exploited in the market. In some cases, logos can be related to other certification schemes, which upcycled products might comply with. Ref. [63] observed that the presence of an organic label increased Chinese consumers' purchase intention for upcycled chicken nuggets. Similarly, using the Carbon logo can improve consumers' WTB [82] and WTP [69] for different types of UFs. However, specific logos indicating the upcycled nature of the products can be used. These logos seem to have a certain appeal among consumers. Bhatt et al. [49], for example, observed that an "upcycled" label is preferred over alternative labels indicating food waste reuse. Upcycled logos have been observed to

increase the acceptance of UFs [26,49], as well as the intention to purchase or willingness to try food with upcycled ingredients [62,64].

Another piece of information that can affect the acceptability of UFs is the indication of ingredients. On the one hand, the indication of ingredients per se may improve the overall acceptability of the product, as observed in the case of upcycled meat [68]. Factors like ingredient origin were observed to be important elements contributing to the likeness of waste-to-value food products [50,65]. Additionally, specific ingredients used may increase consumer acceptance because they are associated with desirable characteristics, such as plant-based protein sources [82] and nutrient-rich seed oils (pumpkin and melons) bearing a geographical indication [80], communicating the naturalness of the product [57] or their origin [56].

The last type of product cues that might be relevant in the formation of consumer responses are intrinsic cues. Factors like color, visual appearance, or damage can influence consumers' responses [49]. For example, Fernandez-Pan et al. [79] observed that the addition of tomato powder to flatbread may cause an intense coloration that is not appreciated by consumers. However, as intrinsic cues are highly product- and process-dependent, their role in determining the consumer response to UFs does not seem to be different from what is observed for conventional foods, and heterogeneity can be observed in the appreciation of intrinsic cues within the upcycled category [91]. As in the case of sensory characteristics (Section 3.5), however, consumer evaluation of intrinsic cues opens the way to the purposeful use of upcycled ingredients to modify specific intrinsic attributes of the product.

3.3. Consumer Characteristics

A significant portion of the literature on the acceptance of UFs has investigated consumers' characteristics that can stimulate favorable intentions and behaviors toward these products. Among these characteristics, factors related to consumers' familiarity with UFs and their knowledge play a major role. Familiarity is usually assessed by asking respondents whether they had already heard of UFs [26,50,66,82] or to specifically indicate their degree of familiarity with them [35,92]. Knowledge is investigated in subjective terms, asking respondents to self-evaluate their level of knowledge [50,52,57,82].

While most studies observe a low degree of familiarity with and knowledge of UFs, only a few of them investigate the effects of these consumer characteristics on consumer responses. Indeed, most studies use the experimental provision of information to operationalize consumer knowledge. In general, familiarity seems not to play a major role in stimulating favorable

consumer responses [35,66]. Conversely, the role of knowledge seems more relevant, as it has been found to positively affect respondents' acceptance of UFs [52,57] and their willingness to pay premium prices [92]. The role played by consumers' previous knowledge of upcycled products thus reinforces the importance of informing consumers [64], for example, through extrinsic product cues, as highlighted in the previous section.

Socio-demographics and lifestyle-related aspects also constitute relevant consumer characteristics. However, as in studies on organic foods [93], the role of socio-demographic characteristics is not straightforward, and studies tend to provide heterogeneous evidence (see Table A2 in Appendix A for a summary of the effects of sociodemographic characteristics). In terms of gender, females tend to express more favorable responses and responses than males [84,94], but inconclusive results are observed as well [60,88,95]. The effect of education level is even less clear, with studies observing positive [60], null [84], and negative results [65]. Age-related findings are more homogeneous, with middle-aged individuals appearing to be more open to UFs according to [10]. However, discordant results are also observed in this case, such as in Hellali et al. [87], where young consumers showed higher WTP levels, or in Cattaneo et al. [95], where age was not a discriminating factor in attitudes toward UF.

Generational levels of consumers have been found to have varying acceptability of UFs. Zhang et al. [96] found that baby boomers (born between 1944 and 1964) had the highest purchase intention for UFs among all generations. Conversely, Perito et al. [56] found that generations X (ages between 40 and 54) and Y (ages between 25 and 39) had the

highest willingness to try UFs.

The heterogeneous evidence about socio-demographic characteristics can be explained if we consider these characteristics not as the primary drivers of consumers' responses, but rather as proxies for broader social conditions, such as individual norms and values [97]. In this sense, consumers' psychological and personality traits may be better explanatory factors for their preferences toward UFs.

In terms of personality, several traits have been investigated in the literature. Consumers' environmental concerns are generally associated with more favorable attitudes and intention to buy UFs [61,82]. This ecological purchase behavior [98] aligns with the environmental benefits associated with these products. The positive image associated with UFs may also explain the positive attitudes and WTB observed in consumers looking for self-rewards [99], social desirability [84], and social status [61]. Although UFs are not necessarily linked to

specific health benefits, some authors found that consumers who pay more attention to health in their purchasing behaviors display higher WTB and WTP values than other consumer groups [57].

Conversely, some personality traits can hinder the development of favorable responses toward upcycled products. Miolla et al. [57] observed that traditionalist consumers, who attach high importance to their traditional food habits and local food origin, are more reluctant to move toward innovative products, exhibiting lower WTB and WTP. Similarly, consumers' price sensitivity can act as a barrier to the consumption of UFs [70]. In this case, the obstacle is represented not by an a priori aversion to this type of product, but instead by a reluctance to pay higher prices [70]. However, simple price consciousness does not necessarily act as a constraining factor, as highlighted in [61]. If price-conscious consumers perceive UFs to be worth the higher price, they might still be willing to spend more on them.

Finally, some psychological aspects related to the acceptance of UFs are found in the literature. Among these, food neophobia and food technology neophobia are prominent, representing reluctance towards our barriers to new products or novel technological advancements in the production process. Food neophobia appears to be a primary factor worsening consumers' perceptions for UFs, as it does with several other innovative food products, from insect-based food [100] to cultured meat [101]. Studies have observed that food neophobia, as well as food technology neophobia, in a UF context, can be connected with factors that accentuate this negative consumer predisposition, especially related to production processes [94] or low education levels [95]. The extent to

which the two types of neophobias affect consumers' perception of upcycled products might also depend on the product itself. Coderoni and Perito [50,60] observed that both food and food technology neophobia have a relevant impact on the acceptance and purchase intention of waste-to-value foods with upcycled ingredients. However, the relevance of the two may differ in different contexts. For example, a study by Tsimitri et al. [102] on the acceptance of whey-based yogurt observed that consumers who expressed a neophobic attitude represented only a relatively small part of the sample. Similarly, Cattaneo et al.

[95] observed, in a study in Italy, that most of the consumers were neophilic instead of neophobic when it came to UFs. In a similar fashion, risk aversion was described [94,98] to affect the perceived usefulness of technology behind UFs, with risk-averse individuals having lower WTP and intentions to purchase them compared to risk-taking individuals.

3.4 Consumer Perceptions

As depicted in Figure 5, consumer characteristics may play a crucial role in determining how product cues are perceived by consumers. Indeed, as theorized by the Total Food Quality model, consumers' perceptions of product cues, rather than product cues per se, are the direct precursors to purchasing intentions.

Almost all the reviewed studies show that consumers have positive perceptions about the environmental benefits of UFs, which are one of the main drivers of acceptance for these foods [49,52,54,90]. These perceptions about environmental benefits may be related to different specific aspects, such as a reduction in food waste [62,66,85] or perceptions of environmentally friendly production practices and packaging [10].

UFs therefore tend to be perceived as more sustainable than their conventional counterparts [50,54], a perception that can be further enhanced by transparency, clarity, and accuracy in communicating their benefits [83].

It should be noted, however, that the association of UF with waste does not stimulate only positive responses due to perceived environmental benefits related to waste reduction. In some cases, this food-waste association might prompt suspicion and worries, leading some consumers to refrain from accepting this type of food [59].

While the perception of environmental benefits seems to be an established result of the literature on UF acceptance, more heterogeneous results are observed with respect to perceptions about health-related benefits. Specifically, some authors observed positive perceptions of consumers about health-related benefits of UFs [50,57,60,89,90]. In some cases, these perceptions were connected to a higher nutritional value of UFs [65] or to the

presence of specific ingredients [78]. This was the case, for example, of the fiber content in a dairy-based flan dessert [90], or of high-protein, low-fat, and low-calorie characteristics [10]. However, in other cases, perceptions of UFs as healthier than their conventional counterparts appear in the absence of consumer knowledge about the product's composition [22,52], suggesting that a halo effect may be at play.

Conversely, health-related benefits can also be negatively perceived in relation to UFs [94], stimulating negative effects, especially in risk-averse consumers [94,98]. Intrinsic and extrinsic product cues can also lead to the formation of specific perceptions in the fields of taste and overall quality. Often, consumers perceive upcycled products as of an overall higher quality

than conventional ones [64,66], while in some cases, they even develop higher expectations in terms of taste [66], with positive reflections on purchase intentions [96].

Finally, the evaluation of price attributes hinges on how the price itself is perceived by consumers. Indeed, the higher price of upcycled products makes these products perceived as more expensive [83], potentially hindering their acceptance by price-sensitive consumers [64]. However, if consumers are made aware of the additional costs required to produce these products, their perceptions change, potentially changing to considering the higher price a fair one [83].

3.5 Sensory Characteristics

The right side of the horizontal dimension of the model addresses the after-purchase quality experience, which is only achieved after buying or consuming a particular food product. According to Grunert et al. [38], this experience stems from technical specifications, which determines the sensory characteristics of food products and affects consumers' responses (Figure 5).

Among the experienced sensory attributes, taste plays a highly relevant role, and many studies highlighted that tasting UFs positively affects consumer responses. Mehta et al. [86] found that attitudes and intentions of consumers improved for ice cream made with upcycled ingredients after they tasted it. Goodman-Smith et al. [54] observed that the taste of upcycled craft beer in New Zealand turned out to be a major factor in consumer acceptability. Similarly, tasting bread enriched with wine by-products led to higher acceptability among Italian consumers [57], and comparable results were obtained by de Visser-Amundson et al. [103] in their study on potato-based upcycled sandwiches in the Netherlands. Investigating the role of taste in more depth, Lin et al. [77] observed that it is possible to increase the acceptability of UFs by acting on specific taste

components (e.g., sweetness). However, a few cases were also observed where UFs did not perform better in terms of taste than their conventional counterparts. Teslic et al. [104], for example, found no relevant difference in consumer taste evaluation of upcycled pastries in comparison to a conventional counterpart. In other cases, UFs performed worse than their counterparts, as in the case of the lower taste experience for a grass protein-based cocoa drink [105] and flatbread made with tomato by-products [79].

Along with taste, other sensory attributes have been evaluated in the literature, with heterogeneous results. Talens et al. [68] observed that upcycled beef and lamb meat obtained positive scores for several sensory parameters, including appearance, aroma, and texture. Similar results were obtained by Tarjuelo [80] on lamb meat burgers for appearance, while no

relevant difference from the conventional product was observed for texture. In the cereal and baked-goods sector, the aroma of cookies made with hazelnut skin led to higher purchase intentions in an Italian study [73], and the superior odor and aroma of a cherry pomace-filled pastry were highlighted in a Serbian sample of respondents [104]. Conversely, cereal bars with brewers' spent grains, in the study of Stelick et al. [78], scored lower than their conventional counterparts for aroma, as well as for appearance and texture. Similar results for texture were observed by Man Le [106] for upcycled pasta, while no difference in product appearance emerged for upcycled pastries with sour cherry pomace filling [104].

The heterogeneity in the results suggests that the effect of upcycling on sensory parameters may be highly context-dependent, being affected by multiple elements, such as the main product and the characteristics of the upcycled ingredients, as well as the dose at which upcycled ingredients are used [79,106]. While these results hardly allow a generalization of the sensory effects of upcycling, what emerges is the opportunity to use upcycled ingredients to purposefully modify specific product sensory characteristics [75] to improve consumer acceptability.

4. Discussion

Our first research question inquired about consumer response toward UFs. Generally, consumer studies observe positive responses, portraying an optimistic scenario for the development of this food sector. However, some considerations are necessary, especially when examining how the share of studies with positive results varies according to different indicators used to measure consumer responses. Specifically, while most studies found positive results when investigating general attitudes and perceptions, the share of null and negative results increases as we move toward WTB or WTP. Essentially, the closer one

moves toward actual consumption, the more heterogeneity is found in the literature; conversely, the further one moves away from consumption, the more studies agree on a positive consumer evaluation of UFs. This pattern aligns with a phenomenon commonly observed in several behavioral models of consumption, referred to as the 'attitude-behavior', the 'attitude-intention', or the 'intention-behavior' gap [72,107]. This gap is usually due to factors that prevent positive attitudes from translating into actual consumption behaviors [72,108,109]. Hence, the optimistic results emerging from our review should be considered with caution, as their actual translation into real-world impacts might not be straightforward. In this respect, while authors widely use hypothetical techniques to assess consumers' responses to UFs, it seems particularly necessary for

research to provide studies based on more realistic scenarios, where respondents are asked to make real purchases (e.g., experimental auctions). Incentive-compatible studies are, in fact, absent, at least among the studies reviewed in this work.

Improving the consumption of UF can be considered a valuable objective in light of sustainability considerations and food waste reduction. The studies we reviewed identify several levels to expand UF consumption. Specifically, referring to the theoretical model we adopted, the most promising paths to stimulate consumption of UFs are extrinsic product cues and consumer characteristics.

The provision of extrinsic product cues might, in fact, be useful to leverage specific consumer attitudes that are already present in the market or that might appear (or be stimulated) in the future. However, different types of cues exist that might perform different roles. For the purpose of discussion, we inductively classified product cues in three operational categories: “UF-specific cues”, “Easy access cues”, and “Accompanying cues” (see Table A3 in Appendix A for a classification of the studies investigating the three operational extrinsic cues categories). We define “UF-specific cues” as cues that can be used only in UFs due to their intrinsic link with the upcycling process. Examples include labels, certifications, and logos explicitly indicating the upcycled nature of the product, or claims highlighting positive impacts on food waste reduction. The potential of these cues is significant, as they allow clear differentiation of UFs on the market and thus enable the development of ad hoc marketing strategies. However, their effectiveness inevitably relies on consumer knowledge of what UFs are, which is still quite low in many contexts.

A second category of cues emerging from the literature is “Easy access cues”, which contain the cues that, because of upcycling, are relatively easy to attach to the product. This category includes many cues connected to sustainability and environmental preservation that communicate the ‘green nature’ of UFs. These cues appear particularly promising, as

they align well with the attitudes of potential UF consumers, who often exhibit high environmental concerns and ecological purchase behaviors. Unlike “UF-specific cues”, the potential benefits of “Easy-access cues” are not exclusive to upcycled products. However, the valorization of these cues appears less dependent on the knowledge of UFs, as they are possibly appreciated by a larger segment of environmentalist consumers.

The last category of cues studied in the literature can be considered “Accompanying cues”. This category includes cues not specifically related to UFs but communicating specific characteristics of particular products (e.g., organic, healthiness, ingredients, and intrinsic

attributes). As they affect consumers' purchasing decisions, their role might be (as in any other food category) to segment the market to reach specific consumer targets. In this sense, they can play a key strategic role for UF producers, as they allow intra-category differentiation.

While the provision of cues can contribute to increasing consumer response toward UFs, consumer characteristics are another relevant factor. The literature highlights the great importance of individual environmental concerns as a driver of the propensity to consume UFs. This evidence suggests that, especially at the business level, devising sustainability-centered marketing and communication strategies might have great potential in fostering UF consumption. Such strategies would, in fact, allow companies to target environmental consumers and reap the benefits of their increased interest in UFs. From a public perspective, all efforts aimed at increasing environmental awareness possibly contribute to the increase in UF acceptance, despite increasing environmental consciousness being usually considered a long process [110].

Despite the potential positive role of environmental awareness, on a wider market level, a relevant barrier to the spread of UFs appears to be consumer knowledge and familiarity with these products. It follows that any action aimed at improving consumer knowledge of UFs has a significant potential for boosting UF consumption. In this respect, public interventions (e.g., through public campaigns) aimed at increasing the knowledge of these foods might be, in the short term, more effective in promoting UF consumption than those aimed at improving environmental awareness. Beyond this direct effect, knowledge of UFs and their processes can also attenuate the negative effects of other factors, such as food neophobia, risk aversion, or price sensitivity.

On the other hand, the role of private producers is twofold. Usual marketing tools (e.g., advertisement, package information) can be used to directly improve the knowledge of UFs to pursue their own marketing objectives. In addition, the placement of UF products on the market can stimulate consumer familiarity with them. This can potentially initiate a

virtuous cycle, where increased UF knowledge favors higher UF acceptance, generating higher UF demand, which in turn stimulates a wider presence of UFs on the market, leading to a further increase in consumer familiarity with UFs.

Lastly, it is necessary to stress the role played by experienced quality. Despite the relatively scarce investigations on this topic in the reviewed literature, most studies agree on the necessity of a positive sensory evaluation of UFs for consumers to ultimately accept them. As such, it seems important that upcycling processes, even when they add value through extrinsic attributes (e.g., waste reduction claims, sustainability labels), do not undermine the sensory profile of foods. However, relevant opportunities emerge in connection with sensory

evaluation. Specifically, several studies highlighted that upcycled ingredients can be used to confer desirable sensory characteristics to food products, thus improving consumer response.

5. Conclusions

Driven by increased attention to environmental sustainability, the spread of circular economy concepts, and advancing technological possibilities, the literature on UFs is growing rapidly, with consumer-related studies forming an integral part of this body of research.

While UF products are still in their introductory phase in many markets, promising avenues seem to be opening for them. Consumers appear interested and open to purchasing and consuming these products. They consider UFs sustainable, appreciate their quality, and are generally willing to buy them, although these positive impressions do not fully translate into a willingness to pay premium prices.

As expected, the sustainable/environmental motive is the leading factor driving consumer intentions toward these products. This suggests that consumers with strong environmental concerns will likely be the primary target to address for marketing these products. Consequently, emphasizing their environmental benefits appears to be a promising communication and marketing strategy to encourage their consumption.

Additionally, developing appropriate tools, such as certifications or voluntary labels, to communicate the upcycled nature shows potential, as such cues, as well as the intrinsic nature of UFs, are appreciated by specific segments of consumers. Therefore, the development of this type of instrument might be of interest for both private industries, which can add a tool to their marketing toolbox to target specific consumer groups, as well as for public institutions. The latter can, in fact, consider creating such kinds of tools to convey information to consumers interested in the consumption of UFs, basically solving

possible information asymmetry issues.

However, a significant threat to the expansion of the UF sector is the limited knowledge about these products among consumers. This lack of awareness risks undermining the possibility that UFs will be evaluated more favorably than their standard counterparts. Low knowledge can impede the formation of consumer willingness to buy or pay price premiums. In some cases, it may even reinforce the expression of negative individual attitudes, such as food neophobia or risk aversion.

Nevertheless, the potential impact of communication and information actions is highly relevant. Most studies highlight that knowledge of UFs, along with individual environmental concerns, is among the main drivers of positive consumer responses. Based on this, one can expect, from both private and public perspectives (assuming UF consumption produces societal benefits), for the return from information and education actions to be substantial. Considering the growth of the sector in recent years, we acknowledge that our contribution presents a static picture that will need to be expanded and refined in the future. While our innovative contribution was to summarize research discoveries on consumers' responses to UFs using a consolidated theoretical lens, some limitations of our work can be addressed in the future. Among these, conducting a formal quality appraisal of the reviewed studies would make the results more robust, while expanding the research by relying on multiple databases, widening the search string, and including non-English material would widen the scope of the inquiry. In addition, our synthesis of the reviewed literature is based on a counting approach, which was used to detect the direction of consumer responses and of the effects of different factors on those responses. Further research can thus delve deeper into the investigation of the size of these effects, possibly also adopting meta-analysis approaches. Finally, as research on the topic is growing, future reviews can consider focusing on specific outcomes and research designs to investigate, in more detail, selected issues related to the consumer evaluation of UFs.

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Appendix A

Table A1. Coding table for mapping extracted variables into the four classes used in the synthesis of results.

Product cues ¹	Consumer characteristics	Consumer perceptions of UFs	Sensory characteristics
Price (cost)	Familiarity with UFs	Environmental	Taste Aroma
UF labels, logos and certifications (extrinsic)	Knowledge (subjective) of UFs	benefits Health related	Texture Odor
Information on upcycling processes (extrinsic)	Environmental consciousness	benefits	Overall appearance
Waste reduction information (extrinsic)	Health consciousness	Higher nutritional value	Overall liking
Environmental claims and certifications (extrinsic)	Price consciousness	Higher overall quality	
Sustainability claims and certifications (extrinsic)	Traditionalist attitude	Better taste expectations	
Health claims (extrinsic)	Self-reward attitude	Food-waste negative association	
Nutritional claims/information (extrinsic)	Social desirability/Social status attitude	More expensive than conventional food	
Food safety information (extrinsic)	Food neophobia Food technology neophobia		
Organic certification (extrinsic)	Risk aversion attitude		
Indication of origin (extrinsic)	Gender		
Information on ingredients (extrinsic)	Level of education Age		
Brand/Producer name (extrinsic)			
Color (intrinsic)			
Presence of damages (intrinsic)			
Texture (intrinsic)			
Overall visual appearance (intrinsic)			

¹ In parentheses, we report the type of cue (cost, extrinsic, intrinsic) according to the revised TFQ model classification.

Table A.2. Socio-demographic variables.

Variable	Response	Study	Operationalization	Effect (direction)
Gender	General perceptions	[46]	Binary	Females have more favorable attitudes than males
		[78]	Binary	
		[86]	Binary	No gender differences
	Acceptability	[47]	Binary	No gender differences
		[83]	Binary	
	Purchase intention	[87]	Binary	Females have higher purchase intention
		[51]	Binary	No gender differences
		[58]	Binary	
	WTP	[81]	Binary	No gender differences
Age	General perceptions	[46]	Categorical	Young consumers display more favorable attitudes
		[78]	Categorical	
		[10]	Categorical	Middle-aged consumers display more favorable attitudes
		[86]	Categorical	No age differences
	Acceptability	[47]	Continuous	No age differences
		[83]	Continuous	
	Purchase intention	[58]	Categorical	Young consumers have the highest purchase intention; old consumers have the lowest
		[89]	Categorical	Old consumers have the highest purchase intention; young consumers have the lowest
		[87]	Categorical	No age differences
	WTP	[81]	Categorical	Young consumers display a higher WTP
		[46]	Binary	Highly educated consumers

Education	General perceptions		(graduate: Y/N)	display more favorable attitudes
		[78]	Binary (graduate: Y/N)	No education differences
	Acceptability	[47]	Categorical	No education differences
		[83]	Categorical	
	Purchase intention	[51]	Binary (graduate: Y/N)	Consumers with higher education have higher purchase intention
		[57]	Categorical	Consumers with lower education have higher purchase intention
		[58]	Categorical	No education differences

Table A.3. Classification of extrinsic product cues potentially improving consumer response toward UFs in the three operational cues categories used in the discussion. Studies from which the positive role of the specific cue is derived are reported in parentheses.

UF-specific cues	Easy access cues	Accompanying cues
UF labels, logos, certifications and claims [26,50,43,45,56,57,77,86]	Environmental claims (generic) [10,22,43,44,45,46,48,51,52,53,54,76,80,81,87,91,92,95]	Nutritional claims [44,48,52,54,57,60,61,71,86,92]
Information on food waste reduction [46,58,62,63,76,80,86,99]	Sustainability claims [34,45,61,71,82,83]	Health claims [22,43,48,51,52,53,81,84,95]
Information on upcycling processes [58,81]	Sustainability certifications [76]	Origin indication [44,47,52,57,79]
Information on efficient use of resources [46,78]	Innovative product claims [46]	Ingredients information [60,66,76,79,82]
		Organic certification [47,52,57]
		Claims on economic benefits [53,80,86]
		Food safety information [10,44,84]
		Brand/Producer name [26,52,99]
		Quality certifications [73]
		Naturalness claims [22]

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3.2 PAPER 2

Effect of consumer perceptions, product characteristics and communications on the consumer responses towards upcycled foods; a meta-analysis

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Abstract

Upcycled foods (UFs) are the circular economy-based foods which are made from upcycled ingredients- these can be food by-products from food industry or imperfect produce. The consumer acceptability of the UFs depends upon various factors like individual, social, psychological, product characteristics and information available etc. According to literature there are three main factors affecting the acceptability of UFs; consumer perceptions about environmental impact of food production, food product characteristics or cues and communications, messaging or marketing tools. These factors have been studied in literature individually or focusing on a specific country or a region of the world. But there is no combined and quantitative study at global level, hence this meta-analysis represents the first effort made to check the effect of these factors on the acceptability of UFs. A total of 52 regression coefficients (effect sizes) were collected from 10 research articles finalized by systematic PRIMSA protocol. Data was analyzed by random effect model (REM) in three different ways i) a simple REM model, ii) multiple level REM model, iii) one-effect size-per-study REM model in R software and publication bias was assessed by funnel plot and Eger's test. In addition, the robustness of model was assessed by cluster robust variance estimation (CRVE). Results of all the REM models demonstrated that there is a significant positive overall effect of all the three aspects (product, perception and communication) on the consumers acceptability of upcycled foods in the form of purchase intention, willingness to buy or pay. Moreover, the results of Cochran's Q test, t , t^2 , I^2 and H^2 revealed that there is a considerable heterogeneity and variability existing among the studies. Overall, the all these three main factors can act as a catalyst to boost the production and consumption of upcycled foods, however more studies are needed in literature to investigate the individual role of each underlying factor explain the variability and in shaping the consumer responses.

Key words: upcycled foods, consumer responses, perceptions, communications, product characteristics, meta-analysis, REM.

Introduction

The environmental impact of food waste is pretty devastating, and it leads to environmental degradation in terms of losses of valuable resources and functional compounds in foods by products (Grasso et al. 2023;). According to Aschemann-Witzel, et al. (2022) the carbon emissions coming from food waste account for up to 12% globally. In this scenario, food waste management through valorization or upcycling of food by products is a way forward for environmental protection. Recently, the valorization or upcycling of food waste or food by products through the circular economy methods to produce new and innovative foods called “upcycled foods” has been introduced to as a mitigation strategy for food waste management, increased food security and environmental restoration (Sousa, 2021). According to Upcycled foods Association (UFA) upcycled foods are value added foods with positive impact on the environment, produced from food components that would otherwise gone to waste and are consumable by humans (Upcycled food association (UFA), 2020; Upcycled food definition task force, 2020; Thorsen et al. 2022). Aschemann-Whitzel, et al., (2023) provided a comprehensive definition of upcycled foods through a literature review from two different perspective: reducing food waste or avoiding the food waste resources and diversifying its utilization into manufacturing of upcycled foods.

The consumer responses towards these types of innovative foods are the main determinants of acceptability and prevalence of upcycled foods in the market and according to the literature, consumer responses towards upcycled foods vary greatly due to several contributing factors (U Zaman et al. 2024). These factors can be divided mainly into three categories; 1) Upcycled food product characteristics related to the environmental impact (Moshtaghian et al. 2023; Aschemann-Whitzel, 2021), 2) consumer perceptions or contextual factors (concerns or consciousness) of consumers (Aschemann-Whitzel, 2021; McCarthy et al. 2020; Hellali and Korai, 2023; Coderoni and Perito, 2020) and 3) communications about upcycled foods in the form of messaging or marketing strategies (Stelick et al. 2021; Yang et al. 2021; Bhat et al. 2020). In most cases the acceptability of upcycled foods was increased due to positive perceptions of consumers or provision of positive information to the consumers like in Turkey, UK, Europe, Australia, Italy, New Zealand, Sweden, USA and China (Yilmaz and Kahveci, 2022; Grasso and Asioli, 2020,

McCarthy et al. 2019; Aschemann-Whitzel et al. 2022; Coderoni and Perito, 2020 & 20021; Goodman-Smith et al. 2023; Moshtaghian et al. 2023). However, in some studies, like de Visser et al, (2021) It was shown that association with food waste (product characteristic) decreases the purchase intention of consumers for rescue-based foods (RBF) or leftover foods and also Huang et al (2024) revealed negative effect of environmental perceptions in terms of green perceived values (GPV) on the behavioral intention of consumers for upcycled foods. In addition to that there can also be null effect of the consumers' environmental concerns on the acceptability of upcycled foods for example in Canada there was no effect of ecological concerns on the intentions to buy upcycled foods (Hellali and Korai, 2023). Based on the results of these studies it seems that consumer responses towards upcycled foods vary across the individual studies related to environmental aspects.

In the literature, according to Ma et al, (2025) there are only 5 comprehensive review papers found in the literature until 2025 to discuss the consumer acceptability of UFs and to know the consumer preferences about these foods. The first research on consumer evaluation of upcycled foods published in 2014 was discussed in a systematic review by Aschemann-Whitzel and Stangherlin, (2021) on the other hand according to Lu et al, (2024) the first research on consumers and UFs appeared in 2017. Moshtaghian et al (2021) discussed the consumer perceptions or attitudes and food product quality characteristics as main factors for the acceptance of upcycle foods. The contextual factors like communication or information strategies also play a significant role in determining the consumer acceptability of UFs (Aschemann-Whitzel, 2021). The acceptability of upcycled foods in the market in the context of sustainability was discussed through a literature review by Ye et al (2023) and different individual and social factors like word of mouth (WOM) were identified. These comprehensive reviews extracted the information from published literature and discussed the information obtained theoretically or qualitatively. However, the quantitative analysis of determinants of acceptability of upcycled foods is not performed yet.

Moreover, in literature meta-analysis studies are found for other sustainable, eco labeled or green foods; for example Bastounis et al., (2021) conducted a meta-analysis on the effect of environmental sustainability on the willingness to pay (WTP) for eco-labeled foods by collecting data of 35 studies (effect sizes) from literature, the results revealed that consumers were willing to pay premium prices for eco-labeled food products and eco labeling had positive effect on the WTP for eco-labeled foods. Another meta-analysis on consumer environmental perceptions of green foods increased their acceptability (Cheng et al., 2024). However, there could be unusual responses

from consumers due to the hypothetical or non- hypothetical nature of studies; this positive effect was seen stronger in case of hypothetical studies instead of no-hypothetical or real time studies like Li and Kallas (2021) demonstrated in a meta-analysis that the willingness to pay (WTP) for sustainable food products was higher in hypothetical studies than real-time based studies.

In conclusion, these individual MA studies are conducted in different areas of the world focusing on different other sustainable, organic or green foods with varying results, however, the meta-analysis picture of studying the role of different factors in determining the acceptability of upcycled foods is missing. There is no meta-analysis conducted to study the effect of different factors, found in literature on consumer responses towards upcycled foods through a quantitative analysis. In other words, meta-analysis study is not found in literature to study the effect of different underlying factors on the acceptability of upcycled foods in a systematic way. This meta-analysis is the first of its kind to analyze the effect of three different aspects; perceptions or attitudes of consumers about upcycled foods, upcycled foods characteristics or extrinsic cues related to upcycled foods and communications or information's provided to consumers related to upcycled foods etc. on the acceptability of upcycled foods through quantitative analysis. Based on this background and objectives the main research question of this research is:

What is the effect of environment related consumer perceptions, product characteristics, and the information or communication on the consumer responses towards upcycled foods?

To address this research question data was collected through a comprehensive and systematic methodology, in the next sections of this Meta-Analysis paper, methodology of finding and extracting the data, data analysis, results and discussion sections are explained.

Methodology

Data collection

To achieve the objective of this meta-analysis paper the methodology was adopted from Zaman et al. (2025 under review) in which, first of all the relevant studies were retrieved from literature by following the PRISMA protocol (preferred reporting system for systematic meta-analysis). The search was conducted from Scopus database by using specific key words given below as a string:

"Food AND Consumer AND ("circular economy" OR upcycl OR Recycl* OR Reprocess* OR "waste to value" OR "value added surplus" OR "rescue based")"*

During finalization of the papers a specific inclusion and exclusion criteria was set to identify and select the most relevant and most desired research papers according to these key words. The inclusion criteria consisted of only the research papers which were related to the consumer analysis or consumer studies, or marketing analysis, or surveys related to upcycled foods or circular economy-based food products. The publication period focused was 2010 to 2023 and the language of publication was set as English. The exclusion criteria consisted of all the papers irrelevant to the key words or search strings and old papers (published before 2010), review papers and papers related to other foods like organic foods or fortified or functional foods. Also, the review papers, conceptual studies, editorials, data articles, notes, book chapters, discussion articles and editorials were also excluded. After careful analysis of the total literature (n=54) research papers were found related to consumer analysis of upcycled foods between 2010 to 2023 (Zaman et al. 2025 under review). Out of these 54 there were ten

(10) research articles found in which the effect of environmental aspects on the consumers responses towards upcycled foods were studied through regression analysis. The data of regression coefficients (effect sizes) was extracted from these 10 finalized research papers into excel sheets and the total number of entries (effect sizes) obtained (out of 10 research papers) was n=52 related to consumers perceptions or concerns, communications and product characteristics Table1.

After careful finalization of papers and effect sizes for meta-analysis the following quantitative data was extracted from these papers in excel sheet.

- Regression coefficients (perception, product and communication)
- P value
- Standard error
- Sample size
- Country of research
- Year of publication

The regression coefficients (effect sizes) and standard errors are the main component of meta-analysis and are needed to calculate the average effect size of studies accounting for heterogeneity

of data and variability of effect sizes between the studies using random effect model (REM). Out of 52 reported effect sizes, the standard error values of 28 effect sizes were reported in the papers, however for the remaining 24 entries the SE was not directly reported which were calculated by two methods: i). t values corresponding to p values provided in the studies (equation 1) and ii) by confidence intervals (C.I) equation 2 (Nieminen 2022). Following equations are used for these calculations.

$$S.E = \frac{\beta}{t} \dots \dots \dots (1)$$

Where β is the value of regression coefficient obtained from the studies, t is the value of test statistics which is obtained from the corresponding p values (Nieminen, 2022).

$$S.E \frac{(upper\ limit - lower\ limit)}{2 \times Z} \dots \dots \dots (2)$$

where upper limit and lower limit refer to the confidence interval of the regression coefficient reported in the paper and z is the corresponding critical value for the confidence interval. For 90% confidence intervals the z value (critical value) is 1.645, for 95% it is 1.960 and for 99% confidence interval it should be replaced by 2.576 (Nieminen, 2022).

After collection and calculation of all the relevant data the random effect model (REM) (Dersimonian and Lair, 1986) given below (equation 3), was used to estimate the pooled effect size, assuming that the true effects may vary across studies due to underlying differences.

$$Y_i = \mu + u_i + \epsilon_i \dots \dots \dots (3)$$

where Y_i is the observed effect size from study i , μ is the overall true effect, u_i is the between-study random effect with variance (τ, τ^2) and ϵ_i is the sampling error. This is a simple random effect model with only the pooled effect or the cumulative effect of all the effect sizes (regression coefficients) on the final response of consumers. In addition to this, another REM model (Berkey et al. 1995) was applied containing the moderators or independent variables (perceptions, communications and product) and the respective effect sizes (β) was regressed on these moderators

to check that weather these moderators explain the variability and heterogeneity in pooled effect sizes. The meta regression model (equation 4) containing the moderators is given as:

$$Y_i = \beta_0 + \beta_1(\text{product})_i + \beta_2(\text{perception})_i + \beta_3(\text{communication})_i + u_i \dots\dots\dots (4)$$

Where:

Y_i : Effect size from study i

β_0 : Intercept

β_1 : moderator “product characteristics” β_2 : moderator “perception of consumers”

β_3 : moderator “communications or information”

$u_i \sim N(0, \tau^2)$: Between-study random effect (heterogeneity)

Table 1. Quantitative data obtained from studies

ID	Place	Year	sample size	Independent variable	Dependent variable	Beta	S.E	p value	Notes
1	Italy	2020	477	Env. perceptions	Purchase intention	1.547	0.305	0.01	S.E given in the paper
2	Italy	2020	477	Env. perceptions	Purchase intention	1.617	0.318	0.01	S.E given in the paper
3	Italy	2020	477	Env. perceptions	Purchase intention	0.489	0.229	0.05	S.E given in the paper
4	Italy	2020	477	Env. perceptions	Purchase intention	0.623	0.251	0.05	S.E given in the paper
5	Italy	2020	477	Env. perceptions	Purchase intention	1.509	0.43	0.01	S.E given in the paper
6	Sweden	2023	681	Env. friendly preparation. a (product)	Attitude	0.002	0.002	0.438	S.E calculated from C.I (95%)
7	Sweden	2023	681	Env. friendly packaging (product)	Attitude	0.002	0.003	0.457	S.E calculated from C.I (95%)
8	Sweden	2023	681	Env. organic production (product)	Attitude	0.007	0.003	0.005	S.E calculated from C.I (95%)
9	Sweden	2023	681	contribution to food waste reduction (product)	Attitude	-0.003	0.002	0.095	S.E calculated from C.I (95%)

10	Sweden	2023	681	Env. friendly preparation. b (product)	Attitude	0.002	0.003	0.453	S.E calculated from C.I (95%)
11	Sweden	2023	681	Env. friendly packaging. b (product)	Attitude	0.002	0.004	0.592	S.E calculated from C.I (95%)
12	Sweden	2023	681	Env. local production. b (product)	Attitude	0.003	0.004	0.481	S.E calculated from C.I (95%)
13	Sweden	2023	681	contribution to food waste reduction. b (product)	Attitude	-0.007	0.003	0.014	S.E calculated from C.I (95%)
14	Turkey	2022	447	solution to food waste (product)	Purchase intention	1.346	0.346	0	S.E calculated from t value
15	UK	2022	106	carbon Label trust (communication)	W.T.P	1.81	0.27	0	S.E given in the paper
16	UK	2020	106	carbon Label. FN (communication)	W.T.P	1.86	0.81	0.02	S.E given in the paper
17	UK	2020	106	carbon Label trust*age (communication)	W.T.P	-0.06	0.2	0.77	S.E given in the paper
18	UK	2020	106	carbon Label trust *gender(communication)	W.T.P	0.31	0.42	0.45	S.E given in the paper
19	UK	2020	106	Carbon Label *Education (communication)	W.T.P	-0.1	0.18	0.57	S.E given in the paper
20	Italy	2021	317	env benefits (perceptions)	Purchase intention	1.868	0.403	0	S.E given in the paper
21	Australia and UK	2020	329	food waste consequences on env. (Australia) (perception)	Purchase intention	0.34	0.103	<0.001	S.E calculated by t value
22	Australia and UK	2020	329	food waste consequences on env. (Australia) (perception)	Purchase intention	0.38	0.116	<0.001	S.E calculated by t value
23	Australia and UK	2020	329	food waste consequences on env. vasp (Australia) (perception)	Purchase intention	0.32	0.124	<0.01	S.E calculated by t value
24	Australia and UK	2020	329	food waste consequences on env. Vege. (Australia) (perception)	Purchase intention	0.32	0.124	<0.01	S.E calculated by t value
25	Australia and UK	2020	358	food waste consequences on env. Ferment. (UK) (perception)	Purchase intention	0.19	0.096	<0.05	S.E calculated by t value
26	Australia and UK	2020	358	food waste consequences on env. vegetable powder (UK) (perception)	Purchase intention	0.18	0.091	<0.05	S.E calculated by t value
27	Australia	2020	358	food waste	Purchase	0.21	0.106	<0.05	S.E

	a and UK			consequences on env. ferment (UK) (perception)	intention				calculated by t value
28	Canada	2023	1014	Ecological consciousness. (perception)	perceived ease of use	0.299	0.091	<0.001	S.E calculated by t value
29	Canada	2023	1014	Ecological consciousness. (perception)	perceived ease of use	0.167	0.051	<0.001	S.E calculated by t value
30	Canada	2023	1014	Ecological consciousness (perception)	perceived ease of use	0.168	0.051	<0.001	S.E calculated by t value
31	Netherl and	2023	1057	environmental benefits. beans (communication)	Moral feelings	-0.14	0.071	<0.05	S.E calculated by t value
32	Netherl and	2023	1046	environmental benefits. insect (communication)	Moral feelings	-0.13	0.066	<0.05	S.E calculated by t value
33	Italy	2020	852	environmental benefits. TENV female (product)	Purchase intention	-0.035	0.08	0.658	S.E given in the paper
34	Italy	2020	852	environmental benefits. TENV age (product)	Purchase intention	0.041	0.027	0.13	S.E given in the paper
35	Italy	2020	852	environmental benefits. TENV middle school (product)	Purchase intention	0.106	0.396	0.789	S.E given in the paper
36	Italy	2020	852	environmental benefits. TENV high school (product)	Purchase intention	0.188	0.37	0.611	S.E given in the paper
37	Italy	2020	852	environmental benefits(product)	Purchase intention	0.231	0.365	0.526	S.E given in the paper
38	Italy	2020	852	environmental benefits(product)	Purchase intention	0.031	0.182	0.867	S.E given in the paper
39	Italy	2020	852	environmental benefits(product)	Purchase intention	0.216	0.177	0.221	S.E given in the paper
40	Italy	2020	852	environmental benefits(product)	Purchase intention	0.436	0.262	0.096	S.E given in the paper
41	Italy	2020	852	environmental benefits(product)	Purchase intention	-0.031	0.264	0.906	S.E given in the paper
42	Italy	2020	852	environmental benefits(product)	Purchase intention	-0.218	0.099	0.028	S.E given in the paper
43	Italy	2020	852	environmental benefits(product)	Purchase intention	0.583	0.147	0	S.E given in the paper
44	Italy	2020	852	environmental benefits(product)	Purchase intention	0.504	0.12	0	S.E given in the paper
45	Italy	2020	852	environmental benefits(product)	Purchase intention	0.817	0.16	0	S.E given in the paper
46	Italy	2020	852	environmental benefits(product)	Purchase intention	0.116	0.365	0.751	S.E given in the paper
47	Italy	2020	852	environmental	Purchase	0.46	0.328	0.161	S.E

				benefits(product)	intention				given in the paper
48	Italy	2020	852	environmental benefits (product)	Purchase intention	0.812	0.315	0.01	S.E given in the paper
49	Italy	2020	852	environmental benefits(product)	Purchase intention	0.897	0.317	0.005	S.E given in the paper
50	Canada	2023	1014	Ecological consciousness. (Perceptions)	Purchase intention	0.299	0.210	0.154	S.E calculated by t value
51	Canada	2023	1014	ecological consciousness. (Perceptions)	Purchase intention	0.167	0.105	0.111	S.E calculated by t value
52	Canada	2023	1014	ecological consciousness. (Perceptions)	Purchase intention	0.168	0.231	0.465	S.E calculated by t value

Source: Authors' own elaboration

Data analysis

The data was analyzed in R software by using *metaphor* package which commonly used in meta-analysis studies Viechtbauer, W. (2010). We first calculated weighted mean effect sizes using a simple random-effects model (REM) in R software and then a REM model with moderators was applied. The restricted maximum likelihood (REML) estimator was used to estimate the overall effect of all the effect sizes on consumer responses or acceptability of upcycled foods. The heterogeneity and variability among the studies were determined by tau (τ), tau squared (τ^2), Cochran's Q test I^2 and H^2 . τ^2 (tau squared) indicates the estimated variance between the effect sizes of the studies and it tells how much real difference exists between the studies. While τ (square-root of tau) indicates the standard deviation of effect sizes and tells us about the variability across the different true effects sizes and how they deviate across the overall effect size. To interpret effect size homogeneity across studies Cochran's Q statistic indicates the statistical significance of heterogeneity; however, when the number of included studies is small, its ability to detect true homogeneity is low. Therefore, in addition to Cochran's Q statistic, the I^2 index was measured to report the extent of heterogeneity. The I^2 index, which is not sensitive to the number of included studies, is reported as a percentage (%) or proportion and represents the proportion of total variance across studies due to heterogeneity. Generally, an I^2 index of 75% or higher indicates high variation (Baker et al, 2022). I^2 also tells that the total variability due to heterogeneity in the studies is not due to sampling error while the H^2 is the ratio of total variability to sampling variability. In addition to that, for the visual demonstration of the dispersion of effect sizes across the studies forest plot was

used. The publication bias was assessed by funnel plot (visual demonstration) Viechtbauer, W. (2010) and further it was confirmed by applying the Eger's regression analysis test (Egger et al. 1997).

In addition to the simple REM model, multilevel meta-analysis was performed by using the code `rma.ml()` in the `metafor` package in R software (Assink and Wibbelink, 2016). In this model, to assess the between-study variance component was determined due to the limited number of studies ($k = 10$), which can lead to unstable variance component estimates and overly conservative inferences in model. Therefore, to check the sensitivity and robustness of the model, one-effect-per-study and Cluster Robust Variance Estimation (CRVE) was performed in REM to check the robustness of the results because multiple regression coefficients were extracted from the same study (Pustejovsky and Tipton 2022). Moreover, the moderation effect of all three factors, i.e. communication, product and perception on the pooled effect sizes of the study was also determined in the multi-level REM model.

Results

A random-effects meta-analysis was conducted using the restricted maximum likelihood (REML) method. The results of the REM model shown in the table.2 depict that the overall effect of environmental aspects on the consumer responses towards upcycled foods is statistically significant ($p < 0.0001$) and positive which is consistent with prior literature. Because several studies contributed to multiple effect sizes, a three-level meta-analytic model was subsequently estimated to account for the clustering of coefficients within studies. In this model, the between-study variance component was small, and the overall pooled effect became non-significant. However, the loss of significance may reflect the limited number of studies ($k = 10$), which can lead to unstable variance component estimates and overly conservative inferences in multilevel models. To further verify the robustness of the findings, cluster-robust variance estimation (CRVE) was performed on the initial random-effects model. The CRVE results confirmed the significance of the pooled effect ($\beta = 0.31$, $SE = 0.098$, $t(4.8) = 3.16$, $p = 0.026$), suggesting that the positive association is not an artifact of within-study dependence. Together, these findings indicate a robust overall positive relationship between the predictors and the outcome, even after accounting for potential clustering. The results from the multilevel model are reported (table.2) for completeness but should be

interpreted cautiously due to the small number of clusters, whereas the single-level random-effects model with CRVE is considered the most reliable estimate in this context.

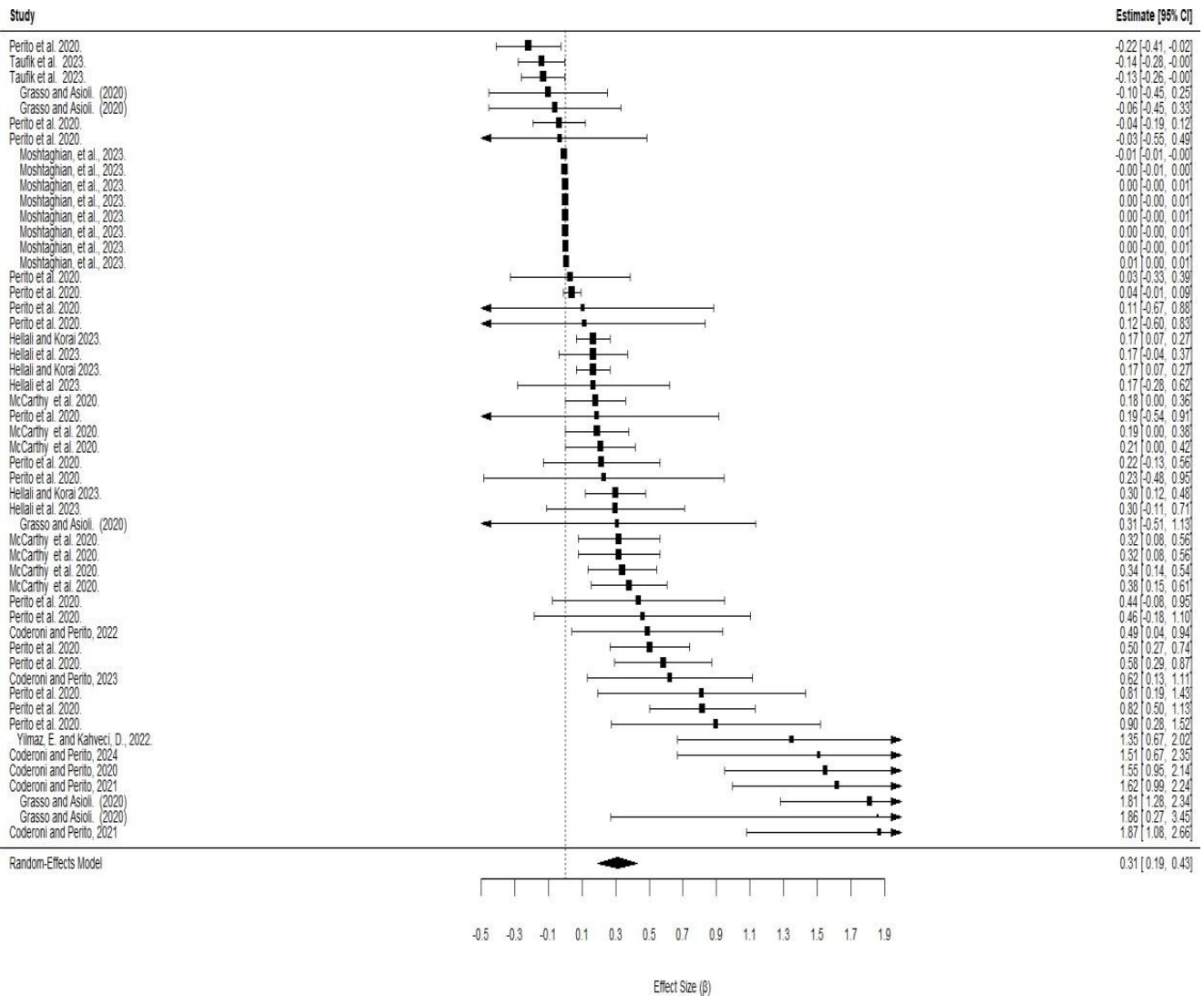
Over all these results show that the pooled effect of environment related parameters; products characteristics, consumer perceptions and communications or messages put a positive effect on the consumer responses i.e. attitudes, purchase intention, willingness to pay or acceptability of upcycled foods. However, the results of the multilevel REM model with moderators did not show any significant effects of individual moderators and also these don't explain the heterogeneity between the studies. Therefore, the main focus of the discussion is on the simple REM model, with one-effect- per-study and multilevel REM model without moderators because these showed significant and positive results according to the literature (table.2).

Table 2 Estimates of different Random Effect Models (REM)

Model	Estimate	S. E	Z value	P value	C.I lb	C.I ub
Simple (REM)	0.3117	0.0603	5.17	<0.0001	0.1935	0.4300
One-effect-per study (REM)	0.6756	0.2480	2.7239	0.0065	0.1895	1.1617
Multilevel REM	0.4524	0.1615	2.8005	0.0051	0.1358	0.7689

Source: Authors' own elaboration

Figure 1 Forest plot depicting dispersion of beta across the studies.



Source: Authors' own elaboration

As far as the model fit measures are concerned, the model fit statistics from the simple REM model meta-analysis indicate adequate model performance (Akaik information criteria AIC =

76.88; Bayesian information criteria BIC = 80.75; corrected AICc = 77.13 and log likelihood logLik = -36.44). The values of AIC and BIC suggest a good balance in model fit, while the corrected AIC (AICc) accounts for the moderate number of included studies, reinforcing the suitability of the selected model structure.

Heterogeneity and Variability:

The heterogeneity and variability statistics demonstrate that there is a considerable variability across the studies; the value of estimated τ (tau)= 0.3874 and τ^2 (tau-squared)

=0.1501, S. E=0.0364) demonstrate a meaningful dispersion of effect sizes. In addition to that the values of I^2 (99.96%) and H^2 (2787.16) also depict that there is substantial variability in the studies and also it is evident that this variability is mainly due to real differences across the studies rather than the sampling error. These results justify the use of a random effect model (REM) in this study. Moreover, Cochran's Q test values ($Q= 360.23$, $df=51$, $p<0.0001$) also strongly support these findings.

Publication biasness check

A funnel plot was used to assess potential publication bias. The funnel plot showed a rather skewed distribution of effect sizes (figure.1), with a relative paucity of small studies reporting negative or no effects.

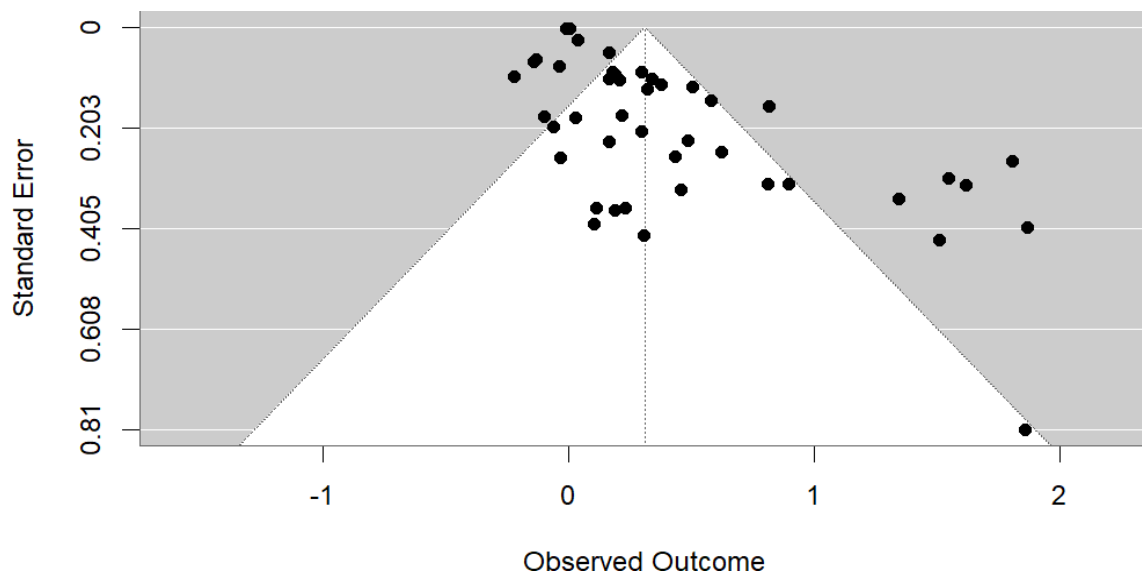


Figure 2. Funnel plot visually showing the publication bias

Source: Authors' own elaboration

Egger's analysis test (Egger et al. 1997) was conducted to statistically assess funnel plot asymmetry, as a common indicator of potential publication bias or small-study effects. The results revealed a statistically significant asymmetry as indicated in Table 2. This suggests that smaller studies may systematically report larger effect sizes or that null or non-significant findings are less likely to be published, thereby introducing a potential bias in the overall meta-analysis estimate underscoring the importance of pooled effects interpretations (Egger et al. 1997).

Table 3 Egger's test for the quantitative assessment of publication bias

Test	Statistic	Value	95% C. I	P -value	Interpretation
Egger's test intercept	Intercept (b)	-0.0047	-0.0088, -0.0006	<0.0001	Significant Asymmetry; possible publication bias
Egger's Test (t statistic)	t	6.73	-	<0.0001	Confirms asymmetry statistically

Source: Authors' own elaboration

Discussion and implications

According to the findings of a simple random effect model (REM) it is clear that the environmental factors related to upcycled foods like upcycled foods product characteristics, consumer perceptions about environmental impact of these foods and the communications or information provided to them significantly affect the responses of consumers toward upcycled foods collectively. In other words, more precisely we can say that for every unit increase in collective efforts made in the form of environmental messaging to enhance the perceived environmental benefits or in the form of enhancing the product characteristics or product cues there could be 0.3117 units increase in the consumer's favorable responses towards upcycled foods.

However, the results of the REM model with moderators showed the inability of individual moderators to explain the variability and heterogeneity among the studies which can be attributed to the smaller number of effect sizes (studies) available in the literature at this moment. Due to the less number or not enough effect sizes available per moderator, the effect of individual moderators cannot be judged at this time (Guolo & Varin, 2017; Cuijpers et al. 2021). In addition to that, the findings related to the publication bias showing study effects with non-significant or null results are less likely to be published or underreported and studies reporting stronger positive effects are more

likely to be published can also be attributed to the very limited literature (Li and Kallas, 2021). Hence, the individual effect of each environmental aspect on consumer responses can be better explained if more studies are available in the literature.

The findings of this meta-analysis highlight the pivotal role of combined efforts in the form of environmental or sustainability perceptions about upcycled foods or environmental or sustainability cues in the form of product characteristics like recycled packaging, environment friendly preparation, local production and green messaging and communication in the form of eco-labeling or marketing in shaping consumer responses toward upcycled foods. The statistically significant and positive effect reinforces the notion that consumers increasingly value environmental responsibility in their food choices. This aligns with prior evidence in the domains of eco-labeled foods Bastounis et al., (2021), green foods (Cheng et al., 2024), and sustainable foods (Li and Kallas, 2021) where sustainability and environmental aspects have consistently driven higher acceptance and positive consumer responses. Similarly, upcycled foods present particularly a promising opportunity within the circular economy narrative, as they combine environmental stewardship with food waste valorization. These findings can lead towards new era of boosting the upcycled foods production and consumption directing the upcycled food manufacturers, retail and marketing managers to shape the future of these foods to a broader spectrum in the market (Thorsen et al. 2022)

For researchers especially psychologists, these findings call for deeper exploration into how environmental framing can interact with attitudes, intentions and behaviors of people to higher acceptability of these foods in market and also these findings can help in lessening the behavioral gaps (Attitude-intention-behavior) found in the literature for other green foods (Wang et al. 2021; Duong, 2022; de Sio et al. 2024). For policymakers, the implications are clear: by promoting the widespread adoption of upcycled food innovations and emphasizing the environmental narratives may not only foster consumer trust but also contribute to broader sustainability goals at the intersection of upcycled food production, waste reduction, and circular economy. Hence, these collective efforts can lead to the positive responses of consumers in form of positive attitudes, higher purchase intentions, higher willingness to pay (WTP) or more acceptability of UFs. These environment related aspects can also act as levers for boosting production and consumption of upcycled foods. Conclusively, the research implications of this study are vast and long term in terms of upcycled foods products marketing, industry, policy making and regulations and also for research directions.

Conclusion

In conclusion, the literature on the consumer acceptability of upcycled foods, especially the systematic and quantitative studies are missing. There are only few systematic reviews found in the published literature and the meta-analysis are completely unavailable. This meta-analysis paper is first of its kind to represent the quantitative analysis of regression analysis related to consumer acceptability of upcycled foods by the consumers. In this meta-analysis study regression coefficients were extracted from research papers which were finalized through a systematic way by using PRISMA methodology. Only those papers were selected in which effect of product characteristics, consumers perceptions and communication or messaging was determined through regression analysis. Apart from the regression coefficients (effect sizes), different other quantitative data was extracted like standard errors to check the trend of effect sizes across different studies. As this is the first of this kind of quantitative study for the acceptability of upcycled foods, therefore the methodologies were adopted from the acceptability of other innovative or new foods like organic foods, green foods or functional foods. Data was analyzed by metaphor package in R software and the results show that the accumulative effect of all the three factors on acceptability was positive and highly significant. But when it comes to the individual effect of all the determining factors on the consumer acceptability of upcycled foods it shows vague results because the number of studies in literature are not enough available to draw a clear picture at this moment. There is need for extensive quantitative studies to bring up more data about regression coefficients so that the individual role of product characteristics, consumer perceptions and communications strategies or messaging can be determined easily.

Overall, this meta-analysis paper highlights the important role of different environmental aspects for boosting the production and consumption of upcycled foods especially with respect to the producers and policy makers. These findings also reinforce the fact that all the stake holders; producers, consumers, marketers and also the researchers; who work on the research and development of upcycled foods, can take benefit from these potential findings to promote the production and consumption of upcycled foods aiming to play a substantial role in environmental protection, food security and sustainability. However, there is still a need for more studies to examine the role of individual factors in this collective effort. This meta-analysis study opens a gateway to enhance the capability of literature to explain this gap.

Limitations

Like other meta-analysis studies this meta-analysis paper has some limitations also; in this study only the regression coefficient data was collected for meta-analysis. However, there could be other data of consumer responses available in the forms of percentages, mean or average which is not counted in this study. The second limitation is related to the concise data from 2010 to 2023, but there is a number of publications reported after 2023 which must also be counted in this type of meta-analysis so that a broader picture of results can be seen.

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3.3 PAPER 3

Analyzing the drivers of consumers' attitudes and intention to buy upcycled food products. An application extending the theory of planned behavior.

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Abstract

Purpose – Upcycled foods (UFs), produced through the re-use of food by-products, are a promising solution to food waste. Since their market success depends on consumer acceptance, this study has two objectives: (1) to assess the role of multiple personality traits in shaping attitudes toward UFs and (2) to assess the relevance of the attitude–intention gap – commonly found for “green foods” – for UFs.

Design/methodology/approach – A theoretical model was grounded on the theory of planned behavior (TPB). Data were collected through an online survey on a representative sample of 904 Italian consumers. Structural Equation Modelling was used to analyze data and test the model hypotheses.

Findings – Consumers' environmental concerns and knowledge of UFs are the main attitudinal drivers, identifying these as the main levers to increase UF consumption. Conversely, attitudinal barriers such as food neophobia and traditional consumption habits are weak, suggesting that consumers do not have strong prejudices against UFs. However, a relevant gap exists between attitudes and purchasing intentions, which risks undermining efforts in increasing UF attitudes.

Originality/value – The article sets a comprehensive framework for studying antecedents of UFs purchase intention, contributing to the sectorial literature that usually investigates a few factors at a time. While UFs are considered “green foods”, their technology-intensive production and connection to food waste require ad hoc research, making the transposition of insights from other “green foods” literature critical. From a theoretical perspective, we contribute to understanding the role of food neophobia, testing whether it should be considered an antecedent of attitudes or an attitude-intention moderator.

Keywords Circular economy, Green food, Theory of planned behavior, Food consumption,

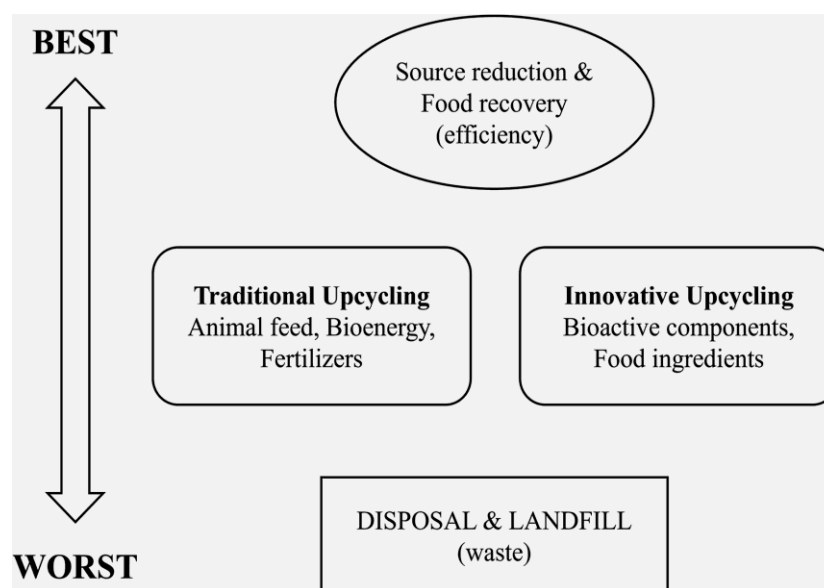
Novel foods, CB-SEM

1. Introduction

At the global level, approximately one-third of the food produced annually for human consumption is wasted (Oztuna Taner, 2024). In Europe, according to Eurostat (2023), food waste amounts to around 58 million tons per year. This situation not only generates issues of social justice – around 800 million people suffer from food insecurity (Todd and Faour- Klingbeil, 2024) – but it also contributes to the exacerbation of environmental issues, as a relevant amount of resources is used to produce food that is then wasted.

The acknowledgement of these problems led to the theorization (and implementation) of circular economy models, which, as opposed to linear ones, aim at reducing waste while increasing efficiency in the use of resources. A recent review by Bangar *et al.* (2024) conveniently summarizes the different approaches for dealing with food waste (Figure 1). An overall rethinking of the supply chain, reducing food loss and waste, is considered the most efficient strategy in a circular economy perspective. Upcycling is the second-best strategy, both in its traditional forms (e.g. production of bioenergy, animal feeds and fertilizers) as well as a way to create value-added foods (innovative upcycling).

Figure 1. Approaches to food waste management. Source: Adapted from Bangar *et al.* (2024).



Value-added foods created from upcycling techniques can be classified as “green foods”. Indeed, while a precise and consensual definition of “green foods” is difficult to retrieve (de Sio *et al.*, 2024; Durif *et al.*, 2010), this term usually indicates a broad category of food products that have a lower environmental impact throughout their entire life cycle (de Sio *et al.*, 2024; Paul *et al.*, 2016). In this respect, their alignment with circular economy principles ensures that upcycled foods (UFs) increase the efficiency of the use of resources, with potential environmental benefits (Moshtaghian *et al.*, 2024). Although food upcycling is recognized as an efficient strategy for food waste management, the production and consumption of UFs depend on the acceptability and response of consumers. To promote their consumption, it is important to understand which are the individual levers and barriers that affect the formation of consumer intentions to buy and consume UFs. The scientific literature on other “green foods” has already investigated several factors that promote and hinder their consumption, such as in the case of organic (Singh and Verma, 2017), biodynamic (Troiano *et al.*, 2020) and sustainable products (Bahraseman *et al.*, 2025). To some extent, some authors also analysed some of these factors in relation to UFs (Hellali and Korai, 2023; Grasso *et al.*, 2023). However, so far, only a few factors at a time have been considered, and a broader picture is still missing. Relying on a behavioural model integrating the theory of planned behaviour (TPB) with evidence from the literature on other “green foods”, we aim at answering the following research question:

R1. What are the factors that affect the intention of consumers to purchase UF products?

Our aim is to contribute to the knowledge of the behavioural processes leading to the consumption of UFs. In fact, while these products fall into the category of “green foods”, they differ from other green products for the role that technology plays in their production process (Cattaneo *et al.*, 2019; Hellali and Korai, 2023) and their connection to waste (de Visser- Amudson *et al.*, 2021; Zhang *et al.*, 2021). These peculiarities might change the role played by some factors involved in the formation of purchase intention.

As “green foods”, however, UFs might be subject to some dynamics observed for other products in the category, as the so-called “green-gap”. The term refers to a gap that hinders the full translation of consumer intention to buy or consume “green foods” into actual behaviour (intention-behaviour gap, as in de Sio *et al.*, 2024), or that exists between a general positivttitude

toward “green foods” and the actual intention to purchase them (attitude-intention gap, as in Wang *et al.*, 2021; Duong, 2022). Given the relative novelty of the topic, the importance of this gap for UFs has not yet been assessed, to the best of our knowledge. Studying its relevance, however, is important to predict the effectiveness of interventions stimulating consumers’ attitudes toward UFs. A wide gap can in fact jeopardize the effects of actions on levers and barriers of consumer attitudes. Conversely, if the gap was small (or if it did not exist), even moderate stimuli could produce relevant results. Therefore, our second research question is the following:

R2. To what extent does a gap exist between consumers’ attitudes toward UFs and their intentions to purchase them?

To answer these research questions, in the next section, a theoretical framework is built and used to develop research hypotheses. In the third section, the methodology is described, followed by a presentation and discussion of the results. Conclusion and limitations close the manuscript.

2. Theoretical Model and Research Hypotheses

The theoretical model used in the study is shown in Figure 2. The TPB (Ajzen, 1991) constitutes the core of the model, being one of the most common theories in behavioural economics. In food economics, it has been used on a variety of products, from organic (Chen, 2007, 2009), to insect-based (Bae and Choi, 2021), to genetically modified foods (Kim *et al.*, 2014). According to TPB, attitudes, social norms and behavioural control directly affect the individual behavioural intention. Our first three hypotheses are directly derived from these assumptions:

H1. Consumers’ attitudes towards UFs positively influence their purchase intention.

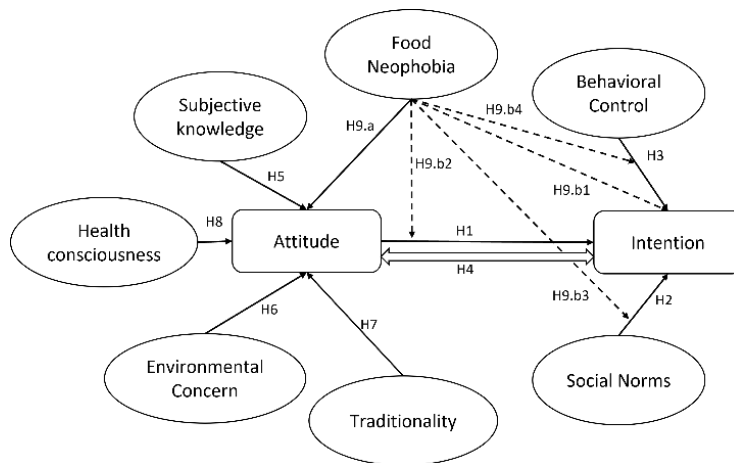
H2. Consumers’ subjective norms positively affect the intention of consumers to purchase UFs.

H3. Consumers’ perceived behavioral control positively affects consumers’ intention to purchase UFs.

The TPB postulates that a positive consumer's attitude leads to the formation of a positive behavioral intention. However, literature on “green foods” often reports the existence of a gap between attitudes and intentions. Vermeir and Verbeke (2006) identified such a gap for sustainable dairy products, observing that people had a lower intention to purchase the products than what might have been expected from their positive attitudes. Wang et al. (2021) trace back this gap to the presence of some “reasons-against” the purchase of these products. As UFs are characterized by a “green” component, we expect the “green gap” to be relevant also in their case:

H4. There is a gap between the attitude and the intentions of consumers to buy UFs.

Figure 2 Theoretical model based on TPB.



Note: The dotted arrows show the alternative hypothesis (H9b)

Source: Authors' own elaboration

While H4 answers our second research question, the first one is addressed adding to the TPB core additional factors potentially relevant in the behavioral process. Specifically, based on the literature on “green foods”, we included five additional constructs: subjective knowledge, environmental concern, traditionality, health consciousness and food neophobia.

Subjective knowledge is defined as the awareness, familiarity, or knowledge of the matter consumers are dealing with (Al Mamun et al., 2018; Tunca et al., 2024). In general, when

consumers know a product, they develop positive attitudes toward it. This has been observed in multiple cases, such as for surplus meals (Pandey et al., 2023), algae-based foods (Bahraseman et al., 2025) or bread enriched with wine by-products (Miolla et al., 2023). Hence, on the basis of this literature, we propose the following hypothesis:

H5. Subjective knowledge of UFs positively affects the attitudes of consumers towards UFs.

Environmental concern is defined as the degree to which people think about the impact of specific processes, products, or services on the environment and feel an urge to participate in solution-oriented activities (Paul et al., 2016; Bahraseman et al., 2025). The positive effect of the environmental concern of individuals on their attitudes is well acknowledged for organic products (Chen, 2007, 2009; Ahmed et al., 2021), local foods (Kumar and Smith, 2018) and other “green foods” (Kim et al., 2014; Paul et al., 2016; Yadav and Pathak, 2016). Since, like these products, UFs fall within a logic of sustainable consumption, we hypothesize that:

H6. Environmental concerns positively affect the attitude of consumers towards UFs.

Traditional foods are foods connected with the customs, values, traditions and the local culture of an area (Aschemann-Witzel et al., 2023). Traditionality, indeed, is a factor that plays a role in food choices, pushing consumers to prefer foods that are part of their culture and their habits while being sceptic, if not hostile, towards products that are not part of their cultural patrimony (Yang et al., 2021). In this respect, UFs might be perceived as relatively distant from traditional foods. Grasso and Asioli (2020) observed that “traditionalist” consumers are indeed more inclined towards traditional foods than UFs. Yang et al. (2021) observed that respondents prefer traditional peach crisps more than the upcycled counterparts. We therefore suppose that:

H7. The importance individuals attach to traditionality in food consumption negatively affects their attitude towards UFs.

Another factor frequently considered when analysing food consumption behaviours is health consciousness. However, anticipating the role of health consciousness in the acceptance of UFs might be difficult. Focusing on intrinsic attributes, there seems to be no reason to consider UFs healthier or nutritionally better than their standard counterparts. Health consciousness might thus not find a “fertile ground” on which to stimulate the formation of positive attitudes. However, two other factors might play a role. On the one hand, the use of technology-intensive processes and food production residuals as ingredients can make consumers doubt the safety and healthiness of UFs (Hellali and Korai, 2023), thus producing a negative response from health-conscious consumers. On the other hand, through a “halo effect”, frequently observed for “green foods” like organic (Sundar and Kardes, 2015), consumers might transfer the positive impression generated by other attributes (e.g. lower environmental impact) to the health dimension. In this case, health-conscious consumers would have more favourable attitudes. Given these contrasting potential effects, we propose a conservative hypothesis:

H8. Health consciousness does not significantly influence the consumer attitudes towards UFs.

Food neophobia is defined as a form of psychological fear, reluctance, or resistance to trying or consuming new foods (Tunca et al., 2024; Coderoni and Perito, 2020; Cattaneo et al., 2019). As, in our context, UFs are quite novel (they are almost absent in the Italian market), we expect food neophobia to affect consumers’ acceptance and the intention to purchase them. However, literature investigating the role of food neophobia provides contrasting evidence about the path through which food neophobia affects consumer purchase intentions. Some authors consider food neophobia a determinant of attitudes (Cattaneo et al., 2019), where consumers’ predisposition toward novel products shapes the very attitude toward these products. Other authors (e.g. Tunca et al., 2024; Kim et al., 2014) conceptualize food neophobia as affecting behavioural intention in two ways: (1) directly and (2) moderating the effect of attitude on intention. Based on these different theorizations of the effect of food neophobia, we try to contribute to the field by empirically testing these two different views, thus proposing alternative hypotheses:

H9a. Food neophobia negatively affects the attitude of consumers towards UFs. H9b.1. Food neophobia negatively affects the intention of consumers to purchase UFs.

H9b.2. The relationship between attitude and intention to purchase UFs is moderated by food neophobia.

H9b.3. The relationship between subjective norms and intention to purchase UFs is moderated by food neophobia.

H9b.4. The relationship between perceived behavioral control and intention to purchase UFs is moderated by food neophobia.

3. Methodology

A questionnaire with 48 questions divided into 3 sections was prepared. In the first section, basic information is provided about UFs (Appendix A). Therefore, our results are to be considered valid conditional on consumers having a basic knowledge of UFs. However, this strategy allows us to ensure a basic level of awareness in a context, the Italian one, where consumers are not familiar with UFs (Chiaraluce et al., 2024). The second section of the questionnaire contains questions that measure the specific constructs included in our model. In this respect, 7-point Likert scale items retrieved from the literature were used (Table I.A in Appendix B). In the questions, we do not refer to a specific upcycled product, but rather to the generic category of UFs. The implications of this choice are discussed in the discussion and conclusion sections. Eventually, the final section of the questionnaire collects socio- demographic information of respondents.

The questionnaire was tested by running a pilot study on 52 respondents to assess the consistency and validity of the constructs. The final sample consisted of 904 Italian consumers, above 18 years old, stratified by age, gender and region of residence to be representative of the Italian population. The administration was performed online by a specialized market agency in February 2025 [1].

The decision about the sample size was made following standard practices in the literature. Specifically, a 10:1 ratio of participants to questionnaire items is considered adequate (Yadav and Pathak, 2016; Aminizade et al., 2024). In our case, this would have implied 500 respondents. To

remain conservative, we decided to work with a larger sample size, which grants us a ratio of approximately 18:1.

The choice of Italy as the national context where to conduct the study was motivated by the study being part of a wider national project (iNEST – Interconnected Nord-Est Innovation Ecosystem) that has, among its objectives, the promotion of research activity and technology transfer in the agri-food sector. Some studies have already investigated consumer perceptions of UFs in Italy, highlighting, in addition to a general low knowledge on the topic (Chiaraluce et al., 2024), a potential acceptance of these products (Coderoni and Perito, 2021), at least in some consumer segments (Coderoni and Perito, 2020; Miolla et al., 2023). However, no previous study analyzed the preferences for UF products in Italy through a structured behavioral model, making the Italian context a relevant one to be investigated. In addition, the choice of Italy might spread further light on the acceptance of UFs in a country where these products are relatively rare on the market. In fact, despite the existence of companies that are involved in the production of UFs [2], the market presence of UFs remain scarce.

To analyze data, covariance-based structural equation modelling (CB-SEM) was used as the dataset is large (Zhang et al., 2021). The data were analyzed in R software using the lavaan package. To model the moderation effect of food neophobia, a two-step method was used, first creating the moderation terms and then putting them in the structural model of SEM as suggested by Becker et al. (2018). Before creating the moderation terms, variables have been scaled in two different ways: mean centred scaling and standard deviation scaling (Little et al., 2006). After comparing the standard indicators of model fitness (Root Mean Square Error of Approximation, Comparative Fit Index, Tucker–Lewis Index, Standardized Root Mean Square Residual) for the two scaling procedures, we proceeded with standard deviation scaling.

4. Results

4.1 Description of the sample

The data collection strategy allowed the sample to be representative of the Italian population in terms of gender, age and region of residence. Specifically, for gender, the share of respondents was similar in the two classes, 48.23% males and 51.77% females (Table 1). In terms of age, the highest number of participants (28.98%) are over 65 years old, while the youngest are the smallest age

group (8.85%). In terms of education level, most of the participants had a high- school diploma (40.15%) or a middle-school education (36.62%). The size of the family is relatively heterogeneous, with most of the respondents living in two- and three-person families, but with a non-negligible share of larger as well as single-person families. While most of the respondents (68.81%) declared a yearly income lower than 35,000 euros, 78.83% of them consider their income status at least quite good. The regional distribution of respondents is reported in Table II.A in Appendix B.

Table1 Sociodemographic characteristics of the sample

Participant Demographic	Percentage (%)	Participant Demographic	Percentage (%)
Gender		Annual Income	
Male	48.23	Less than € 10,000	13.83
Female	51.77	€ 11,000 to € 20,000	22.57
Age		€ 21,000 to € 35,000	32.41
18-24	8.85	€ 36,000 to € 50,000	14.27
25-34	11.50	€ 51,000 to € 75,000	7.74
35-44	14.49	€ 76,000 or more	2.21
45-54	19.47	I do not want to declare/I do not know	6.97
55-64	16.70	Family Income Status	
Above 65	28.98	Very difficult	4.58
Education		Difficult	5.09
Primary school	1.99	Modest	13.83
Middle school	36.62	We are quite well	36.39
High School	40.15	We are well	27.99
Bachelor's degree	7.41	We are very well	14.05
Master's degree	10.07	I prefer not to answer	1.33
Postgraduate (PhD)	3.43		
No formal Education	0.33		
Family members			
1	14.49		
2	31.97		
3	27.43		
4	19.69		
5 or more	6.42		

Source: Authors' own elaboration

4.2 Construct consistency and validity

All the constructs have been tested for i) consistency, through Cronbach's Alpha; ii) convergent validity, through Average Variance Extracted (AVE); and iii) discriminant validity, through Fornel-Larker Criteria. The results of the tests are reported in Table 2. Cronbach's Alpha is greater than 0.8 for all constructs, which demonstrates that the items used for measuring the latent variables are highly reliable and consistent. Average variance extracted (AVE) is above 0.5, supporting convergent validity of each construct. Finally, the Fornel-Larker value is greater, for each construct, than the correlation coefficients with other constructs (Table. III.A, Appendix B), which indicates a good level of discriminant validity, suggesting that all the constructs are conceptually well-separated from the others.

Looking at the mean values of the constructs (Table 2) respondents scored particularly high on environmental and health consciousness. Relatively high average values are also observed for most of the other constructs, except for subjective knowledge and food neophobia. As hypothesized, the sample has relatively low knowledge about UFs. However, on average, respondents seem not particularly reluctant to try new products. This appears in line with Cattaneo et al. (2019), who reported the neophilic nature of Italian consumers towards new food technologies

Table 2 Means, standard deviation (SD), and test values for the measured constructs

Construct	Reference	Mean (St.Dev.)	Alpha	AVE	FLV
Attitude (AT)	(Paulet al. 2016)	5.05 (1.28)	0.95	0.762	0.873
Behavioral Control (BC)	(Mehta, 2023; Chen, 2007)	5.08 (1.22)	0.89	0.607	0.779
Social Norms (SN)	(Mehta, 2023; Kumar and Smith 2018; Pandey et al. 2023; Paul et al. 2016)	4.80 (1.33)	0.95	0.760	0.872
Environmental Concerns (EC)	(Paul et al. 2016; Pandey et al. 2023)	5.54 (1.25)	0.91	0.666	0.816
Health Consciousness (HC)	(Tunca, 2024)	5.54 (1.13)	0.93	0.658	0.811
Subjective Knowledge (SK)	(Tunca, 2024)	3.97 (1.54)	0.95	0.797	0.893
Food Neophobia (FN)	(Coderoni and Perito, 2020)	3.65 (1.31)	0.85	0.541	0.736
Intention (INT)	(Tunca, 2024)	5.10 (1.37)	0.94	0.847	0.920
Traditionality (TD)	(Sogari et al, 2023)	5.16 (1.22)	0.81	0.529	0.728

Source: Authors' own elaboration

4.3. Regression results and hypothesis decision

The regression results of the models with the different specification of the role of food neophobia are reported in Table 3, while Figure 2 graphically reports the estimated paths of the accepted model. The fit indices of the two models, which support the adequacy and robustness of the specification, are reported in Table IV.A in Appendix B.

Both models provide similar indications, supporting the robustness of the results. All expected relations from the TPB model are confirmed, leading to acceptance of H1, H2 and H3. A Chi-Square (χ^2) likelihood ratio test for equality to one of the attitude-intention parameters confirms the existence of a gap between attitudes and intentions, as maintained by H4. Similarly, all hypotheses about the determinants of attitude are supported (H5, H6, H7 and H8), with positive effects estimated for environmental concerns and subjective knowledge, a negative effect for traditionality and no effect for health consciousness. Among these factors, the positive ones are estimated to play a more relevant role, in magnitude, than the others. Finally, the results suggest that food neophobia should also be considered a determinant of attitudes, since its effect is significant in the first model (H9a), while none of the expected relationships (H9b.1, H9b.2, H9b.3, H9b.4) are confirmed in the second model.

Table.3. Regression results and hypothesis acceptance

Path	Hypothesis	Model 1		Model 2		Decision
		(β)	p-value	(β)	p-value	
Attitude → Intention	H1	0.658	0.000	0.652	0.000	Accepted
Social norms → Intention	H2	0.380	0.004	0.352	0.008	Accepted
Behavioral control → Intention	H3	0.661	0.000	0.710	0.000	Accepted
Subjective knowledge → Attitude	H5	0.511	0.000	0.567	0.000	Accepted
Environmental Concerns → Attitudes	H6	1.052	0.000	1.071	0.000	Accepted
Traditionality → Attitude	H7	-0.123	0.078	-0.189	0.004	Accepted
Health consciousness → Attitude	H8	0.070	0.251	0.102	0.098	Accepted
Food Neophobia → Attitude	H9a	-0.115	0.051	-0.116	0.048	Accepted
Food neophobia →	H9b1	-	-	0.010	0.847	Rejected

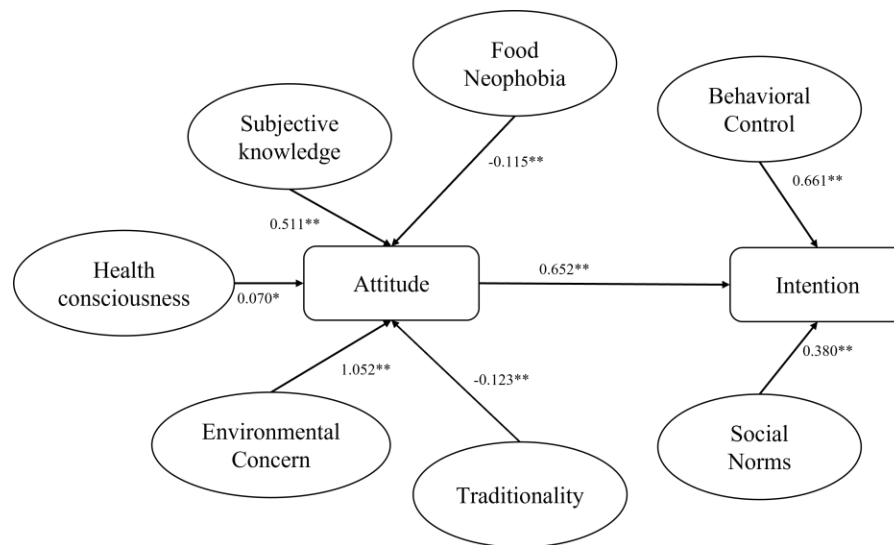
Intention						
(Attitude x Food Neophobia) → Intention	H9b2	-	-	0.061	0.694	Rejected
(Social norms x Food Neophobia) → Intention	H9b3	-	-	0.144	0.221	Rejected

(Behavioral control x Food Neophobia) → Intention	H9b4	-	-	-0.156	0.232	Rejected
Attitude ↔ Intention (Gap)	H4	LR test (χ^2)	p-value	LR test (χ^2)	p-value	Accepted
		5.29	0.021	6.19	0.013	

Note(s): R^2 values: (Model 1): Attitude – 0.641; Intention – 0.782, R^2 values (Model 2): Attitude – 0.641; Intention – 0.782

Source: Authors' own elaboration

Figure 3 Path diagram with Effect sizes



Note: Asterisks (*) and double-asterisks (**) indicate statistical significance at 10% and 5% level, respectively.

Source: Authors' own elaboration

5. Discussion

Grounding the investigation on the TPB, our study confirms, for UFs, the positive effects of attitude, social norms, and behavioral control on purchasing intention. However, a gap exists such that the attitudes of respondents toward UFs do not fully translate into an actual intention to purchase them. The attitude-intention gap observed in the literature for “green foods” (Wang et al., 2021; de Sio et al., 2024) also applies to UFs. The presence of this gap is an issue for the development of UF consumption, as the potential increase deriving from individuals who are intrinsically more inclined toward UFs is diluted to some extent. However, closing the attitude-intention gap is critical not only to ensure that inner attitudes of individuals are fully expressed but also to preserve the value of efforts aimed at generating these attitudes. Indeed, when attitudes do not fully translate into intentions, the effectiveness of every intervention to foster positive attitudes toward UFs is inevitably reduced, with the consequence of “losing” part of the invested resources. In addition, while we limited the analysis to respondents’ intention, the literature on “green foods” suggests that the attitude-intention gap is only the first part of the story, as there is usually another gap between intention and actual behaviour (Duong, 2022; de Sio et al., 2024). Although the relevance of this additional gap should be specifically evaluated in the case of UFs, its presence might be a further bottleneck.

In this respect, future research should investigate the factors that might reduce these gaps in the case of UFs, possibly drawing from the “green food” literature. Here, in fact, multiple aspects have been investigated, ranging from consumers’ personality traits (Duong, 2022) to their future orientation (Chekima et al., 2017), their involvement in food choices or the perceived uncertainty (Vermeire and Verbeke, 2006). Food neophobia has been proposed as a mediator between attitudes and intention (Tunca et al., 2024). However, in this respect, our study does not support this hypothesis.

Since the existence of positive attitudes is even more important when a gap with intentions exists, it is crucial to unravel the role of factors shaping consumers’ attitudes. Our study identifies environmental concerns as the main determinant of attitudes towards UFs. Thus, any shift in environmental concerns likely translates into significant changes in the perception of UFs. Therefore, good opportunities stem from public awareness of climate change and environmental issues, which have improved greatly in recent years. This is evident in our sample, where the level

of environmental concern is relatively high, in line with other studies on Italian consumers (Miolla et al., 2023; Coderoni and Perito, 2020). However, recent economic pressures might be a relevant threat, turning the attention of consumers away from environmental concerns, with potentially negative reflections on their consideration of UFs. From a business perspective, the relevance of environmental concerns suggests that environmentally conscious consumers are the most prone to move to UFs. As such, companies can strategically target this segment to improve market acceptance of UFs, for example through the selection of “green” communication strategies, the use of sustainable packaging or the choice of specific distribution channels.

The importance of “environmental consumers” could be somewhat expected. However, these consumers are not always the most important segment for “green foods”. For example, for organic products, several authors notice a prevalence of individualistic motives in consumption decisions (Cei and Rossetto, 2024; Diagourtas et al., 2023). Among these, perceived health benefits are quite recurrent. In our case, however, the investigation of the potential effects of health consciousness on consumers’ attitudes led to inconclusive results. In general, we can reasonably exclude a negative association between individual health consciousness and attitude towards UFs. This suggests that consumers do not perceive relevant risks from the association of waste and residues with food. On the other hand, consumers seem able to understand that the benefits of UFs are of an environmental nature, rather than related to health characteristics. In this respect, no evidence of any halo effect, often observed for other “green foods” (Sundar and Kardes, 2015), has been identified for UFs.

Another important driver of consumers’ attitudes is the knowledge of UFs, in line with evidence from other “green foods” (Yadav and Pathak, 2016; Al Mamun et al., 2018). This opens the way to promising avenues for the spread of UF consumption. First, the knowledge of UFs in our representative sample is relatively low, suggesting that there is room for improvement. In this sense, every information action performed by private companies or public institutions can be expected to have a good return in terms of consumer attitudes. As such, investments in information tools, such as marketing campaigns, logos and certifications, offer the prospect of an economic return (for producers) and of an increase in the market share of UFs (for producers and the public).

In addition, the positive association between consumer knowledge and attitudes might also trigger a positive feedback mechanism. When individuals encounter UFs, through advertising, availability, or direct experience, subjective knowledge tends to increase (Kumar and Raju, 2013; Mehta et al., 2023). Currently, market exposure of UFs is quite limited. However, increasing

exposure could initiate a virtuous cycle. Enhanced knowledge stimulates favourable attitudes, strengthening purchase intentions and consumer demand. This, in turn, encourages greater supply and visibility in the market, further increasing exposure and knowledge. This self-reinforcing loop makes knowledge not only a direct driver of attitude but also a foundational element in the broader process of mainstreaming UF consumption.

Turning to factors potentially hindering the development of the UF sector, we focused on food neophobia and respondents' traditional attitude. In both cases, the effect on attitudes toward UFs was negative, despite being low in magnitude. In the case of food neophobia, our contribution also adds to literature identifying food neophobia as a determinant of attitudes (Sabbagh et al., 2023; Cattaneo et al., 2019) rather than intentions, or an attitude-intention mediator, as maintained in other studies (Tunca et al., 2024; Kim et al., 2014). Basically, when individuals do not feel confident in a new food product, the very perception they have of that product is affected (negatively). Afterwards, the intention to buy the product is affected as well, but as a response to the lower attitude that the individual developed.

The low negative effect of food neophobia and traditionality is a promising result, suggesting the presence of low barriers to UF consumption. However, the hypothetical context and the absence of a specific product to be evaluated may have played a role, as the degree to which respondents perceive a product as novel or not traditional might depend on the specific product and its characteristics. Nonetheless, these two factors seem not to constitute relevant a priori barriers to the perception of UFs altogether, despite the fact that strategies to limit their effect should be considered when promoting the expansion of this sector. In the case of food neophobia, some authors suggested that increasing familiarity with the product (e.g. communicating the technologies used and emphasizing their safety and sustainability) can decrease the perception of the product as “new” or “risky” (Ghazanfar et al., 2022). Similarly, communication can soften the role of traditionality. While modern upcycling exploits advanced technologies and processes, the principles of reusing and recycling are rooted in many culinary traditions, aligning with long-standing traditional practices of minimizing waste (Aschemann- Witzel et al., 2023; Miroso and Bremer, 2023). Emphasizing this similarity while portraying upcycling as a modern expression of traditional wisdom could help reduce the preconceptions about traditionality, making even more conservative consumers open to developing a favourable attitude toward UFs.

6. Conclusions

Our study provides preliminary evidence on consumer attitudes and intentions towards UFs, a topic investigated to a limited extent and without a broader vision on the role played by multiple behavioral factors. A main conclusion derived from the analyses is the importance of leveraging, from both a private and public perspective, customers' environmental concerns to stimulate positive attitudes toward UFs while increasing the customers' awareness of these products. Nevertheless, as in other “green” products, part of these efforts might be lost if no ways are found to reduce the gap between consumers' attitudes and their actual purchasing intentions. Conversely, compared to other innovative foods (e.g. insect-based food, cultured meat), UFs seem to be less affected by barriers related to neophobia or traditional food habits, thus alleviating the effort needed to overcome them.

As in all studies, these results should be critically evaluated in light of the characteristics of the research. In addition to the classical issues related to potential self-selection, we acknowledge that the role of factors determining consumer attitudes and intentions may be context-dependent (Randall et al., 2024). Therefore, while we consider the behavioural framework useful for the analysis of consumers' response to UFs, replication in different markets is recommended.

In addition, the absence of a specific product to be evaluated by consumers can increase the hypothetical bias in the results. Although further research should work with real upcycled products, asking respondents about generic UFs allowed us to investigate their attitudes toward the very concept of food upcycling. This allowed us to better investigate, at a general level, factors whose role might critically depend on the specific product proposed to respondents, as might be the case for health consciousness, traditionality or neophobia

Notes

1. An ethical clearance is not necessary for this study, as data are collected by an external market agency, are anonymous, and no personal information is collected (as defined in the Regulation EU, 2016/679). In addition, the collected data are not sensible or confidential in nature, and no vulnerable group is included in the research, as specified in the Declaration of Helsinki.

2. Some examples of these companies are the “Biova Project”, which produces beer from leftovers of household bread, “Packtin”, which produces upcycled ingredients from fruit and vegetable waste, or “Circular Food”, which uses ley flour from spent beer grains to produce bakery products.

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APPENDIX A:

Introduction to upcycled foods

“Upcycled foods are obtained from the ingredients which would otherwise be gone to waste and are value added to make them consumable for the humans. These foods help reduce food waste, improve the sustainability of the food system, and can provide nutritional and economic benefits. Examples include fruit pulp used in energy bars, spent grains in baking mixes, or vegetable peels in flour mixes. The concept of upcycled food is in line with the principles of the circular economy and is gaining traction. However, the acceptability of recycled foods depends on consumer perceptions, attitudes and intentions.”

APPENDIX B

Individual items with factor loadings

Table 3 Individual items with factor loadings

Const.	Code	Loading	QUESTIONS
Food Neophobia (FN)	FN1	0.826	I am constantly sampling new and different foods.
	FN2	0.248	I don't trust new foods.
	FN3	0.863	I like foods from different cultures.
	FN4	0.778	At dinner parties, I will try new foods.
	FN5	0.635	I will eat almost anything.
	FN6	0.879	I like to try new ethnic restaurants.
Subjective Knowledge (SK)	SK1	0.898	I know pretty much about upcycled food products.
	SK2	0.911	I do feel very knowledgeable about upcycled food products.
	SK3	0.878	Among my circle of friends, I am one of the 'experts' on upcycled food products.
	SK4	0.881	Compared to most other people, I know more about upcycled food products.
	SK5	0.898	When it comes to upcycled food products, I know a lot.
Health Consciousness (HC)	HC1	0.834	Health is very important to me.
	HC2	0.880	I care a lot about health.
	HC3	0.863	Health means a lot to me.
	HC4	0.782	I appreciate healthy food very much.
	HC5	0.776	I choose food carefully to ensure good health.
	HC6	0.799	I consider myself a health-conscious consumer.

	HC7	0.750	I often think about health-related issues.
Environmental concern (EC)	EC1	0.83	I am very concerned about the environment.
	EC2	0.78	I would be willing to reduce my consumption to help protect the environment.
	EC3	0.79	Major political change is necessary to protect the natural environment.
	EC4	0.85	Major social changes are necessary to protect the natural environment.
	EC5	0.81	Anti-pollution laws should be enforced more strongly
Social Norms (SN)	SN1	0.87	People who are important to me would buy upcycled food products
	SN2	0.89	People who are important to me would support me if I decide to buy upcycled food product.
	SN3	0.89	People who are important to me would appreciate if I decide to buy upcycled food products.
	SN4	0.88	People who are important to me would approve if I decide to buy upcycled food products.
	SN5	0.87	People who are important to me would encourage me in buying upcycled food products.
	SN6	0.80	People who are important to me would think that buying upcycled food would be a smart choice
Attitude (AT)	AT1	0.89	I like the idea of upcycling of food products.
	AT2	0.89	Upcycling of food products is a good idea.
	AT3	0.88	I have a favorable attitude towards upcycled version of food products.
	AT4	0.85	Upcycled foods products improve my overall health.
	AT5	0.85	Upcycled products are environmentally friendly and produced sustainably.
	AT6	0.85	Upcycled products can generate multiple sociocultural and economic benefits through the consumption and production chain.
Behavioral Control (BC)	BC1	0.76	The decision to eat circular food will be completely under my control
	BC2	0.72	The possibility of buying circular food will be entirely up to me.
	BC3	0.85	I am confident that I will decide to buy circular food.
	BC4	0.7	Eating circular food will be possible for me if they are available on the market.
	BC5	0.83	Eating circular food will be possible for me if they are compatible with my eating habits.

Intention (INT)	INT1	0.93	I will likely buy upcycled food products in the future if they are available for purchase
	INT2	0.92	I plan to buy upcycled food products in the future if they are available for purchase.
	INT3	0.90	I am willing to buy low upcycled food products in the future if they are available for purchase.
Traditionality (TD)	TD1	0.76	My diet mainly consists of traditional foods from my home country/region.
	TD2	0.71	I like to cook traditional foods from my home country/region.
	TD3	0.79	I always prefer traditional foods from my home country/region over others.
	TD4	0.65	When I travel, I miss traditional foods from my home country/region.

Source: Authors' own elaboration

Table 4 Correlation Results of Latent Constructs and Square Root Of AVE (Fornel-Larker Criteria)

Const	AT	BC	SN	EC	HC	SK	FN	INT	TD
AT	0.873								
BC	0.829	0.779							
SN	0.840	0.798	0.872						
EC	0.689	0.685	0.606	0.816					
HC	0.403	0.378	0.362	0.447	0.811				
SK	0.487	0.461	0.506	0.271	0.355	0.893			
FN	-0.354	-0.319	-0.347	-0.240	-0.179	-0.392	0.736		
INT	0.868	0.833	0.805	0.660	0.401	0.432	0.320	0.920	
TD	0.202	0.213	0.206	0.231	0.552	0.341	-0.116	0.177	0.728

Note: The values in bold are the square root of AVE (average Variance Extracted)

Source: Authors' own elaboration

4 CHAPTER IV - DISCUSSION AND CONCLUSION

4.1 General discussion

This thesis explored the behavioral transition required to move from a traditional linear economic system in the agri-food sector towards a circular economic model. The linear system, characterized by the extraction of resources, production, consumption, and eventual disposal of food products, has increasingly been recognized as unsustainable due to its significant contribution to environmental degradation, resource depletion, and food waste. In contrast, the circular economy aims to maintain the value of products and materials within the system for as long as possible through practices such as reuse, recycling, recovery, and regeneration of resources (Kristensen & Mosgaard, 2020). This paradigm shift has been strongly supported by international and regional policy frameworks, particularly those promoted by the European Union through initiatives such as the Circular Economy Action Plan and the Farm-to-Fork Strategy, which emphasize the need to reduce waste and promote sustainable food systems (Arruda et al 2021)

Within this context, upcycling practices in the agri-food sector have emerged as a particularly promising strategy to address the environmental and economic consequences of food waste. Upcycling involves transforming food by-products or surplus materials into new food products with added nutritional or economic value. Several studies have highlighted that upcycling can significantly reduce environmental impacts while simultaneously creating new market opportunities for the food industry. Although the environmental and economic benefits of upcycling are increasingly recognized in both academic and policy discussions, the successful implementation of these practices depends largely on consumer acceptance of the resulting products. Furthermore, these processes can also enhance the resilience of food companies, as they become less dependent on limited resources and more capable of adapting to fluctuations in global markets (Despoudi et al 2021). Nevertheless, the acceptability and success of such products require a thorough assessment of consumer buying behavior and food purchasing patterns.

The literature review shows that the research on upcycled foods is growing rapidly in the last couple of years and consumers are getting knowledge and awareness of upcycled foods, however these foods are still in their introductory phase in the markets, consumers have positive attitudes and perceptions in the beginning but when it comes to actual consumption intentions to buy these

foods the tendency is lowered. This could be attributed to newness which causes development of neophobia, and consumers see these new foods as unusual (Hellali and Korai, 2023) or might be unaware of the actual impact of these foods on environment, economy, society and food security. This has been one of the common hurdles for consumers to accept new foods which are innovative or unusual in the market. Food neophobia has also been found to be the prominent barrier and threat to the expansion of other new foods like insect-based foods (Bae and Choi 2021), algae-based foods (Bahraseman et al 2025), genetically modified foods or cultured meats (Hamlin et al 2022) in the market. On the contrary to that, experience of quality and taste of upcycled foods has been found to play a significant role in the acceptance of these foods. This leads to increase in knowledge and general awareness in the public and more acceptability (Yilmaz and Kahvechi, 2022). In this context the consumer personal characteristics have also been found in literature as an important bridging factor between the product cues (intrinsic and extrinsic) and the consumer buying behavioral process like perceptions, attitudes, buying intention, willingness to pay and acceptability. In addition to that the results depict that the product cues both intrinsic and extrinsic, play a significant role in the promotion and acceptance in the market. Among these factors, price represents one of the most important extrinsic cues, and has already been explored in several studies in relation to consumer price sensitivity. Consumers have been shown to exhibit price sensitivity towards organic and green foods (Lavuri et al., 2022). The consumers were willing to pay premium prices for the upcycled foods and consider these foods as sustainable and environment friendly production as an extrinsic motive and leading factor driving consumer intentions toward these products (Ghazanfat et al., 2022; Miolla et al., 2023; Asioli and Grasso, 2021). Consequently, emphasizing their environmental and sustainability benefits; reducing food waste, reducing food security issues etc. appears to be a promising communication and marketing strategy to encourage their consumption.

Moreover, the knowledge of UFs and their production process has been found to be an important driving factor in promotion and acceptance of these foods. Even more beneficial effect was found on the production and supply chain as a connection developed in the form of boosting the supply and demand cycle in the market. This phenomenon has long rooted connection with policy making and consumer research in the current era of consumption peak where a lot of research is needed in the molding and transformation of consumer behavior towards upcycled foods through knowledge creation and awareness campaigns.

The meta-analysis results also supported this fact that acceptability of upcycled foods can be significantly enhanced by incorporating the combined role of several factors; enhancing communication and knowledge, promoting products intrinsic and extrinsic characteristics, and targeting specific segments of consumers who are more environmentally conscious and have more concerns about environmental protection. These efforts are likely to generate more positive results than targeting consumers who show little concern for the environment. This course of action is also supported by the results of the Italian survey conducted in this thesis, in which the environmental consciousness of consumers showed positive and highly significant effects on their attitudes towards upcycled foods.

Moreover, the so-called attitude-intention gap identified in this research for upcycled foods — similarly to what has been observed for other green, organic, and insect-based foods — could be reduced or overcome by adopting the above-mentioned strategies.

Traditionality may present different scenarios across different cultures, regions, and traditions worldwide. In the present research, Italian consumers, who are already well known for being strongly traditionalist and attached to their own traditional foods, showed negative attitudes towards upcycled foods. However, this may not hold true in other cultural settings.

This research is also subject to several limitations. The first limitation, related to the literature review, is that the data collection was restricted to the period 2010–2023, while numerous publications have appeared after this period. A further limitation related to the research on Italian consumers is that the absence of actual upcycled products on the market and the use of a hypothetical survey may increase hypothetical bias in the results. Additionally, the sample population was drawn exclusively from Italy, which may also represent a limitation, since Italian consumers are known to be strongly traditionalist and to hold unique and specific attitudes towards innovative foods. Therefore, the results could be broader and more comprehensive by incorporating a more diverse consumer sample in future research on upcycled foods.

4.2 Conclusion

This thesis explored in depth the emergence of the need for circular economy in agrifood sector, most importantly enhancing the consumer response towards these agri food products produced from circular economy methods. This thesis was structured in a quite systematic and unique way

describing the introduction, background knowledge of the subject matter; food waste, circular economy, upcycled foods and role of consumers in expansion of these foods in the market. The research questions were based on important research gaps related to upcycled foods and their consumption behavior, which were answered individually by defining specific research objectives. The main objective was related to the identification, assessment and quantitative analysis of various consumer responses i.e. in the form of perceptions, purchase intentions, acceptability, willingness to buy, willingness to pay and sensory evaluations. It was also disclosed how these responses arise in consumers and what type of responses they are; positive, negative, or null. In addition to that, various intrinsic and extrinsic factors, consumer characteristics, cost cues, product quality experience were discussed in detail through comprehensive literature review. The factors affecting the consumer acceptability of upcycled foods were determined through meta-analysis picture and explained with the help of literature on other innovative foods. The comprehensive literature review was performed in totally new way of presenting and discussing the literature through the lens of a food quality model. Through this a declining trend of consumers positive responses and emergence of heterogeneity was identified as the intentions and consumption behavior were explored. The application of a behavioral model; theory of planned behavior (TPB) on the consumer responses from Italy is for the first time resulting in vast and exploratory outcomes which also open a gateway to new era of research on upcycled foods. This thesis presented three different studies on upcycled foods in a very comprehensive way different from another conventional research in this field. These studies can be helpful in all the research areas of consumer research, food marketing, behavioral modeling and product expansion. These findings can also be feasible to apply in food and agriculture economics to study the impact of consumer behavior on the food market and food trade and food import and export.

The future of food consumption behaviors is dependent on these types of innovative research which highlight the path towards a sustainable and environmentally friendly economy.

4.3 Recommendations:

Based on the findings of this research there are some very important recommendations for food producers, marketers, policy makers and researchers, especially concerned with food waste management, upcycling of food waste and generation of upcycled foods. Firstly, all the stakeholders should work together with a common purpose to reduce the generation of food waste to its

minimum, secondly utilize the unavoidable food waste into various forms in agriculture fertilizers, poultry and fish feeds and through adopting innovative and advanced food upcycling methodologies to produce upcycled foods. Thirdly, the food production technologies for food formulations and food recipes should opt for the upcycled food ingredients which should be accompanied by food safety and quality parameters. Thirdly, the food marketing strategies should focus on the consumer awareness, knowledge and familiarity with these foods in the market to mold the consumer behaviors and attitudes towards these foods. In addition to that, the market research on upcycled foods should be more realistic than hypothetical, based on the choice experiments, experimental auctions and sensory evaluations in the market. Fourthly, research institutes should focus on the new food product developments and new varieties of foods which contain the upcycled food ingredients. Hence, all the sectors need to work in collaboration to enhance the production and consumption of upcycled foods at a mega level.

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