UNIVERSITÀ DI FOGGIA

Dipartimento di Scienze Agrarie, Alimenti, Risorse Naturali e Ingegneria

Doctoral Thesis in Management of Innovation in the Agricultural and Food Systems of the Mediterranean Region

– XXXIII cycle –

The adoption of health and eco-innovations to improve quality, food safety and sustainability

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ACKNOWLEDGMENT

The passion for this work as well as the perseverance and the determination were the main reasons for achieving my goals and completing the PhD course with full satisfaction. However, the help and the constant presence of highly qualified people was the indispensable compass that guided me along this journey.

Then, this is the moment to say "*thank you*"!

A special thanks must go to my supervisor **Rosaria Viscecchia** for the trust she placed in me, supporting every choice and decision. Her dedication to work was for me one more reason for commitment and sacrifice. Her practicality in solving problems has been my guide to success. Then, I sincerely hope to maintain this relationship for a future full of professional satisfaction.

Thanks to my co-tutor **Mariarosaria Lombardi** who, directing me towards this path, made me discover my true passion and made me understand "what I want to do when I grow up"!

Thanks to **Francesco Bimbo** who opened the doors of his knowledge to me. His experience and professionalism were indispensable travel companions!

Thanks to **Alessandro Bonanno** who welcomed me to the United States of America making me feel at home. Thanks to **Sachintha Sarani Mendis** and **Armen Kazarian**, for the moments spent together. You made me experience unforgettable emotions!

Thanks to **Giovanna Solito** and the Philadelphia marketing team!

Thanks to all people of the Economic Area of my Department for their encouragement and welcoming me into their family. They are a wonderful team!!!

Thanks to **Marco Tappi**, **Simone Russo**, **Lerato Phali**, **Danial Fatchurrahman,** and more generally to all the girls of the XXXIII Cycle, for all the laughs shared together. Because working well also means having fun!

Last but not least, thanks to my parents and my life partner for always supporting me in every decision! Thanks to my little **Gioia** that is accompanying me in this last part of the journey!

Thanks to all of you…these three years, even if full of difficulties, were memorable!

ABSTRACT

Packaging plays a pivotal role in preserving food quality, integrity and safety along the whole food supply chain. Its importance is also linked to the possible reduction of food loss and waste aimed at promoting more sustainable production and consumption patterns. Actually, at the end of food product use, a large amount of packaging is wasted and often it escapes formal collection and recycling systems and eventually it end-ups polluting our environment. Hence, there is the need to contribute to packaging innovations able to minimize food loss and waste by optimizing the use of the materials such as, active, intelligent and sustainable packaging (e.g., biodegradable and compostable one).

In this context, there is a large room for innovation in the packaging sector in the attempt to enhance food safety and to maintain the quality of products. Also, innovative packaging may have higher chances to satisfy the social needs in increasing the sustainability of individual choices, reaching the Sustainable Development Goals indicated by the 2030 UN Agenda.

In the light of these premises, the aim of this thesis is twofold. First, it is to explore whether consumers are willing to purchase food products packaged with innovative solutions such as active, intelligent and sustainable packaging, as well as to define the determinants of their intentions. Secondly, it is to investigate if the food and drink manufacturers are willing to invest in such packaging innovations.

Then, after a general introduction of these packaging innovations and their application in the food and drink sector, the first part of the work is focused to investigate the consumers acceptance and willingness to pay (WTP) for active, intelligent and sustainable packaging by collecting evidence available in the literature and published between 2005 to 2018. Moreover, in order to reach the aforementioned objectives, 260 Italian consumers were surveyed and 20 Italian micro and small-medium entrepreneurs interviewed.

Preliminary results show that consumer's acceptance and WTP for smart packaging are influenced by the consumer's knowledge about these technologies. Furthermore, most of the consumers are interested in buying food products packed with intelligent packaging rather than the active one to reduce their wastes at home, thanks to the ability of this package to provide real-time use-by or expiration data. Respondents are also willing to purchase foods (e.g., milk) packaged in sustainable packaging (e.g., biodegradable packaging) to improve the environmental wellbeing. Moreover, descriptive statistics show that respondents slightly prefer to purchase products packaged using plant-based (e.g., corn, sugarcane etc.) biodegradable material, rather than the use of organic waste feedstocks (e.g., whey), as well most of the respondents are willing to pay from 1% to 5% more for milk packed in biodegradable packaging, regardless of the raw material used. Finally, most of the interviewed manufacturers are willing to invest in at least one packaging innovation, mainly preferring between the active packaging and the sustainable one (e.g., compostable packaging).

Keywords: active packaging; intelligent packaging; sustainable packaging; consumer's willingness to purchase; manufacturers' willingness to invest.

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PART I: INTRODUCTION

INTRODUCTION TO THE RESEARCH AREA

1. Introduction

Food packaging is an essential component of the Food Supply Chain (FSC) aiming to preserve quality and ensure a longer shelf-life of foods [1-3]. The main functions of primary packaging are to contain food and to protect it from the external environment, in order to preserve its nutritional properties for a longer period of time and of course to facilitate distribution, sale and consumption [4-6]. Providing complete food containment and protection could prevent dangerous leakage and mechanical damage during transport and storage. Then, appropriate containment and protection must be assured through the numerous handling stages that occur from the packaging line to the final consumer use, in order to avoid food losses and waste (FLW) [7].

FAO (2019) defines food loss and waste (FLW) as the decrease in quantity or quality of foods along the whole FSC [8]. In details, food loss (FL) takes place at production, postharvest and processing stages in the FSC. Food waste (FW), on the other hand, occurs at retail and final consumption [8,9]. According to FAO (2011), every year almost 1/3 of the whole foods produced for the human consumption is lost or wasted [10]. The associated global economic cost is estimated to be equal to USD 750 billion [11]. However, the social impact is far greater considering that worldwide some 850 million people live with chronic hunger [12]. Moreover, FLW has also an important environmental impact [13]. It is estimated that it is responsible for the generation of approximately 8% of the total Greenhouse Gas (GHG) emissions [14]. Then, reducing FLW is a global priority in order to avoid financial losses, enhance food security and reduce environmental risks. Furthermore, it provides a critical contribution to achieve the world's Sustainable Development Goals (SGDs), specifically the target 12.3 calls for "helving per capita global FLW by 2030" [8,11]. Reducing FLW also has the potential to contribute in reaching the SDG 2 (End Hunger) and the SDG 13 (Climate Change) [8,15].

Among the various causes of the generation of FLW, deficient packaging material as well as the total absence of packaging are considered some of the main ones, as shown in Table 1 [11,16]. Indeed, as already mentioned, food packaging provides protection against physical damage to preserve food from aesthetic defects that may be cause of rejection from retailers and consumers [7,8]. Moreover, it also provides chemical and biological protection [17]. Chemical protection minimizes compositional changes caused by external environmental influences, such as exposure to gases (e.g., oxygen), change in temperature, relative humidity or exposition to light [2,17,18]. For example, colour change commonly happens when packaged foods are exposed to retail lighting. This could be considered by consumers as an aging symptom and consequently food could be discarded in favour of an apparently newer alternative [7]. Instead, biological protection provides a barrier to microorganisms, insects, rodents, and other animals that could determine serious product infestation with potential risks for human health [7,17]. Finally, the shelf-life of foods is also influenced by intrinsic factors of food such as, water activity, pH value, available oxygen, nutrients and preservatives [2,18]. Then, the shelf-life of packed foods is influenced by the interactions between extrinsic and intrinsic factors [2].

Table 1 - Type of packaging-related food loss and waste from processing and packaging stage to the final consumption.

Food Supply Chain Stage	*Type of packaging-related food loss and waste*	*References*
Processing and packaging	- Problem in the filling process; - Packaging failures while sealing; - Packaging damage; - Packaging problems leading to food spoilage; - Irregular sized packaging; - Packaging changes due to marketing reasons.	8,19-23
Distribution and retail	- Packaging does not provide enough mechanical protection (inappropriate packaging material, poor stackability, no packaging at all); - Damage to barcodes on packaging; - Aesthetic issues or packaging defects.	8,16,22
Final consumption	- Difficult to open packaging; - Difficult to empty packaging; - Inappropriate packaging size (e.g. oversized portions); - Deficient packaging methods and materials that impact the longevity of foods.	8,16,22,24-29

(*Source:* our elaboration from Wohner et al., 2019)

However, the main functions of packaging are not only to contain and to protect food, improving its shelf-life, but also to communicate information and to provide convenience features (Figure 1). Indeed, packaging must provide details required by law such as, ingredients list, nutritional information, weight/volume, manufacturer's or seller's, expiration date (best before/use by dates) and any relevant warning statements [7,22]. Additionally, information on packaging could help consumers to minimize FW giving instructions on how to store, open or cook foods as well as encouraging consumers to freeze leftovers [22]. Finally, packaging plays a vital role in enabling convenient food, contributing to saving time and minimizing effort during food preparation [17,30]. Change in socio-demographics characteristics, such as the emergence of single person households, as well as the change in lifestyle of consumers have led food companies to develop innovative packaging solutions, like single portion and microwavable packaging [30]. Convenience features like easy to handle, to open, to access, and to reseal are important not only to meet consumer needs but also to reduce the generation of household FW. For example, consumers may spill food or drink if the packaging opening results difficult. This is particularly true for old people or for those with disabilities [22]. According to an explanatory study on Swedish households, yogurt and sour milk in liquid packaging boards contributed 75% of the "difficult to empty" waste [26].

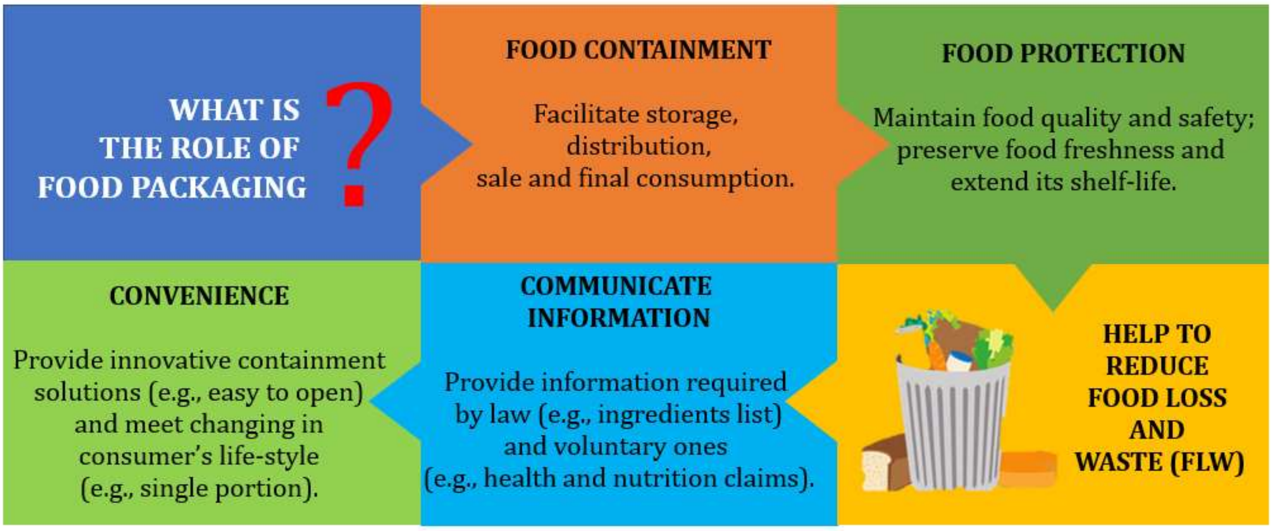

Figure 1. Functions of food packaging. (*Source:* our elaboration from Wohner et al., 2019 and FoodDrinkEurope, 2018).

In this context, improvement in packaging features as well as the adoption of health innovations such as active packaging, able to extend the shelf-life of foods, and the intelligent one, which provides information to the users about the remaining time to buy and consume foods, could help to prevent the generation of FLW as well as to reach the SDGs, adopted by the United Nation Member States in 2015 [30-32]. However, whenever the options for prevention are exhausted, FLW has the potential to be recovered into other production systems (e.g., bio-refineries) [33]. According to the "FW recovery hierarchy", introduced by the European Directive on waste (2018/851), FLW could not only be reused as animal feed or compost, but also diverted to others industrial uses like, energy recovery via anaerobic digestion (Figure 2) [34-37].

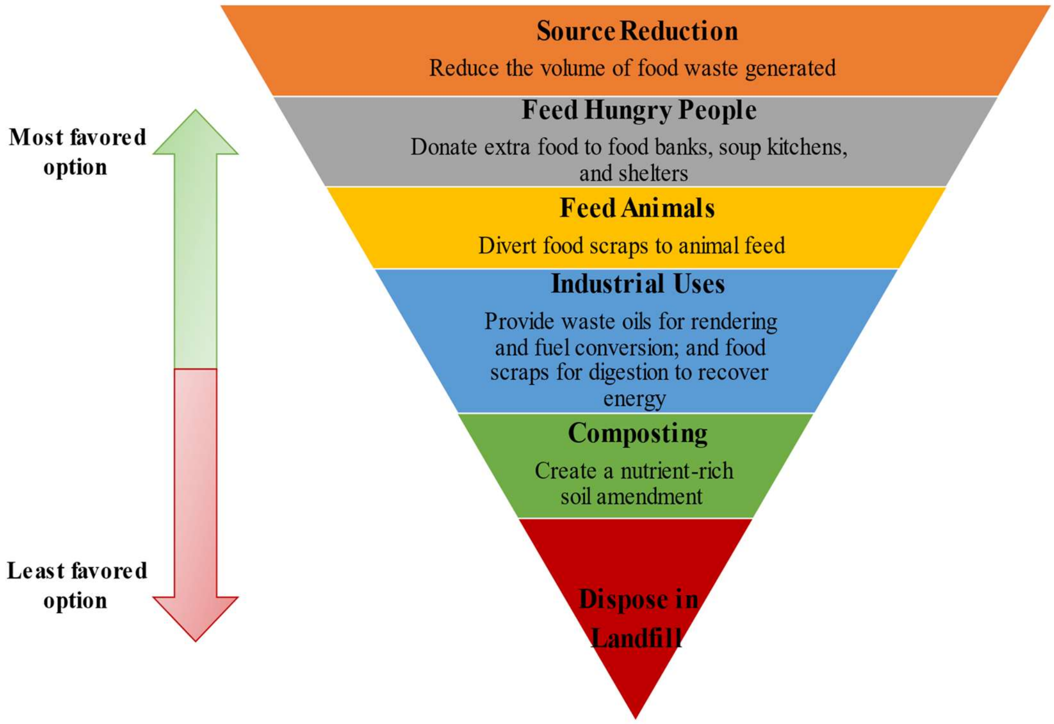

Figure 2. Food Waste Recovery Hierarchy

(*Source:* our elaboration from Garcia-Garcia et al., 2017)

Moreover, increasing efforts are currently being focused on the production of bio-products such as, biodegradable and compostable polymers for eco-innovations in food packaging [33,38,39]. This last option could provide great benefits for the environment thanks to a reduction of methane gas emissions from landfills as well as to a preservation of non-renewable raw materials (e.g., fossil fuels) [39-42]. Furthermore, the adoption of eco-innovations in food packaging can also help to reduce the so-called issue "plastic soup" [43] (Magnier et al., 2019). Indeed, according to FAO (2014), plastic is the second most used material in the packaging market [12]; the most recent data show a global production of 368 Mt in 2019, where China was the biggest producer (31%). Europe (EU-28 plus Norway and Switzerland) reached, indeed, 57.9 Mt highlighting a reduction of 6% [44]. Generally, plastic packaging represents the most important industrial application (on average 30% of the total) in the world [45]. Specifically, polymers, such as polystyrene (PS), polyethylene (PE), polypropylene (PP), and polyethylene terephthalate (PET) were widely used as packaging materials the food and drink (F&D) industry because of their relatively low cost, easy availability and their mechanical characteristics able to provide good barriers to oxygen and carbon dioxide [42,46-48]. However, a large amount of plastic packaging, at the end of its useful life, often escapes formal collection and recycling systems and eventually it leaks away polluting our environment [45,49]. In 2016, it is reported that this amount was equal to 41% of the global plastic packaging production [45]. Hence, there is the need to adopt eco-innovations in primary packaging able to reduce the environmental impact of packages, while maintaining food quality and safety.

1.1 Objectives of the Thesis

In the light of these premises, the aim of this research work is twofold. First, it is to explore whether consumers are willing to purchase food products packaged with innovative solutions such as, active, intelligent and sustainable packaging, as well as to define the determinants of their intentions. Secondly, it is to investigate if the food and drink (F&D) manufacturers are willing to invest in such packaging innovations.

Specifically, with respect to the first objective, this research work tries to replay to the following research questions:

- Are consumers willing to purchase active and intelligent packaging to reduce household food waste?
- What is the technological solution most preferred by consumers between active and intelligent packaging?
- Are the factors that the literature finds affecting individual intention to reduce household food waste be also related to the willingness to purchase active and intelligent packaging to further mitigate the household waste?
- Are consumers willing to purchase foods packaged by sustainable packaging? And then, are consumers willing to purchase milk packed in biodegradable packaging?
- What are the factors that drive consumers toward more ecological purchase decisions?
- How consumer preference changes in relationship with the renewable origin of the milk packaging?
- Are consumers willing to pay for milk packaged in biodegradable packaging made from different raw materials such as, organic waste feedstocks (e.g., whey) as well as plant-based (e.g., corn, sugarcane etc.)?

Moreover, with respect to the second and last goal, this research work tries to replay to the following research questions:

- Are F&D manufacturers aware about their business innovation needs?
- Are F&D manufacturers aware about the existing packaging technologies to achieve their needs?
- Are F&D manufacturers willing to invest in packaging innovations?
- Are F&D manufacturers able to translate their needs into a packaging innovation?

This research will allow us to have a clearer understanding of the factors affecting the consumers' willingness to purchase active, intelligent and sustainable packaging. Moreover, it will help to understand if F&D manufacturers are also interested in the adoption of these packaging innovations. Then, this research will provide useful managerial and policy implications guiding firms towards those most promising technologies as well as identifying the main drivers and barriers in the introduction of active, intelligent and sustainable packaging into the market by Italian micro, small and medium enterprises.

1.2 Structure of the Thesis

The entire thesis is composed of six chapters, which a brief description will be given in the following.

Chapter 1 represents the theoretical background of the research area. It provides a general discussion of the food packaging innovations subject of this study such as active, intelligent and sustainable ones, showing their functions and principal applications in the F&D industry.

Chapter 2 shows the principal patterns affecting the consumer's acceptance and willingness to purchase smart and sustainable packages by collecting evidence available in the literature.

Chapter 3 investigates the consumer's willingness to purchase active and intelligent packaging to reduce household food waste using a structural equation model. Then, the results of this empirical work are reported.

Chapter 4 analyzes the consumer's willingness to purchase milk packed in biodegradable packaging through the understanding of the factors that driver's consumer towards more ecological purchase decisions. In addition, the study qualitatively investigates the consumers' willingness to pay for milk packaged in biodegradable made packaging from different raw materials such as, organic waste feedstocks (e.g., whey) as well as plant-based (e.g., corn, sugarcane etc.). Then, the results of the structural equation model and descriptive statistics are reported.

The Chapter 5 aims at analyzing the F&D manufacturer's willingness to invest for packaging innovations like active, intelligent and compostable ones to meet a specific business need.

Chapter 6 presents the general conclusions of this research work. It discusses the findings in terms of addressing the research questions and the implication in the F&D market.

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Chapter 1

RECENT TRENDS IN FOOD AND DRINK PACKAGING

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Abstract: This chapter discusses the principal applications of nanotechnology in food packaging to enhance food quality and safety as well as to reduce the environmental impact of packages at the end of their useful life. Therefore, active packaging, able to extend the shelf-life of foods, and intelligent packaging, able to inform about food's freshness, are introduced. Finally, compostable packaging especially made from organic waste feedstock are discussed as examples of sustainable food packaging applications.

Keywords: nanotechnology, active packaging, intelligent packaging, compostable packaging.

1. Introduction: nanotechnology

Nanotechnology is the study of manipulation of matter in atomic and molecular scale [1,2]. According to the European Commission (Recommendation 2011/696/EU) "nanomaterial means a natural, incidental or manufactured material containing particles, in an unbound state or as an aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimensions is in the size range 1 nm-100 nm" [3].

The incorporation of nanoparticles along with packaging material gives the opportunity to generate new types of food and drink (F&D) packaging with improved barrier properties [4-7]. Nanotechnology applications in food packaging are also able to provide two more advantages: incorporation of active compounds to provide functional performance and sensing of relevant information [2,8]. Specifically, these types of packaging could contain substances that are able to extend the shelf-life of foods by preventing the causes of deterioration (active packaging) or they could identify and inform about the presence of chemical and biological deteriorating elements that are able to change the internal packaging atmosphere (intelligent packaging) [6].

Finally, nanomaterials are mainly used for plastics, considering that currently the majority of packaging materials are petroleum-based [9]. However, the application of nanotechnology could open new possibilities to improve the mechanical, thermal and gas barrier properties for bio-based packaging materials [8,10,11]. Figure 1 summarizes the Nano food packaging applications, stressing the main functions and feature.

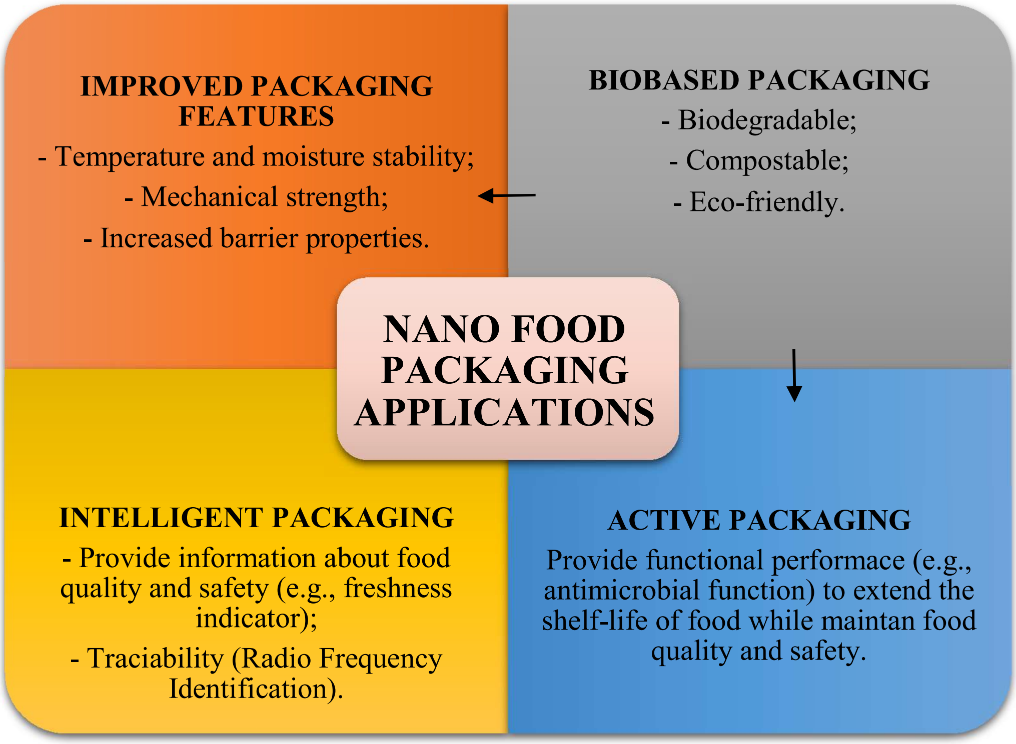

Figure 1. Nano food packaging applications, functions and features

(*Source:* our elaboration from Kuswandi et al., 2016)

The main risk related to nanotechnology applications is their potential toxicity [2]. Indeed, recent studies found that nanoparticles can migrate from packaging to foodstuff [7]. For instance, Echegoyen and Nerin (2013) showed that the migration of Nanosilver from commercially existing food containers, which are claimed to be microwavable, was higher when time and temperature were increased [12]. Although the observed amount of nanomaterial migration seems to be lower than the limitation of the European Union (EU) legislation [12,13] (Fortunati et al., 2012; Echegoyen and Nerin, 2013), the potential risks for the human health are still unclear [14]. The EU Regulation 450/2009/EC, which integrated the Regulation 1935/2004/EC, established that the single substances, or the combination of substances, used to make an active or intelligent component should be authorized after the European Food Safety and Authority (EFSA) has performed a risk assessment of substance migrations from food contact materials into food [15-17]. One passed this safety assessment; the nanomaterial will be listed as an approved food contact material [14]. Moreover, the same regulation specifies that active and intelligent materials should be labeled, with the word "do not eat", to inform consumers about non edible parts and then avoid accidental consumption [18].

Despite the concern over toxicity effects (Siegrist et al., 2008), new food packaging technologies based on nanomaterials are receiving increasing attention by the F&D

industry. In 2014, the global nanotechnology-related F&D packaging market was equal to USD $7.3 billion and active technology represents the largest share of the market with USD $4.35 billion sales [8]. According to a more recent market overview, the active and intelligent packaging market was valued at USD $17.5 billion in 2020, and is expected to reach a value of USD $25.16 billion by 2026, registering a CAGR of 6.78% during the forecast period of 2021-2026 [19]. Thus, nanotechnology applications in the F&D industry will play an increasingly important role in the future [20].

The chapter goes on to illustrate the principal trends in the F&D packaging with a specific focus on the role of health innovations such as active and intelligent packaging as well as on eco innovations like the biodegradable and compostable ones.

2. Health innovations: active and intelligent packaging

2.1 Active packaging

The EU Regulation 450/2009/EC defines active materials as: "materials that are intended to extend the shelf-life of foods and to maintain or improve the condition of packaged food. They are designed to deliberately incorporate components that may release substances into the packaged food or the surrounding environment or absorb some substances from food or the environment" [16,21]. Therefore, active packaging controls the quality and safety of the packaged product and it is able to change the environmental conditions inside the package whenever it is necessary [22]. Furthermore, this technology has the potential to reduce FW, giving consumers the largest possible time to buy and consume foods [23].

In detail, active packaging refers to the incorporation of several substances, directly into the packaging material or in a separate container (e.g., sachet, label) inside the package, which can absorb (scavenger) or release (emitter) gaseous matter [6,22,24]. Then, scavengers are able to remove any undesired substances found inside the packaging (e.g., oxygen, moisture, ethylene, carbon dioxide) guarantying stable conditions during storage and enhancing the shelf-life of foods [22,24,25].

For instance, ethylene is a phytohormone released by most fruits and vegetables after they are harvested [26]. It induces ripening, quickens softening and inevitably leads to deterioration of fresh and minimally processed fruits and vegetables [21,26]. Therefore, the use of ethylene scavengers plays a key role in prolonging the shelf life of many types of fresh produce [27].

The presence of moisture inside the packaging is another important cause of food spoilage [21]. It causes microbial growth, softening of dry crispy products, and caking of hygroscopic products like milk powder, instant coffee powder, sweets, etc. [28]. Moisture absorbent pads are also commonly used for controlling liquid from foods like fish, meat, poultry, fruits and vegetables. Moreover, a study conducted by PortoConte Ricerche (2015) showed that a moisture scavenger could extend the shelf life of "spianate", typical Sardinian bread, from 6 to 28 days [29].

Today the most popular and widely used active packaging is designed to remove oxygen (O2) from inside the packet [6,21]. O2 is responsible for the growth of aerobic microbes, off flavour and odour development, colour changes, and nutritional losses [21,30,31]. Therefore, the incorporation of oxygen scavengers into food packages is important to decrease the oxidative effects of foods such as meats, sausages, milk powder, or spices [21,6]. O2 can also be avoided through antioxidant agents added into packaging materials [26]. For instance, lipid oxidation is one of the main causes of deterioration of fish during its processing and storage. The use of film with antioxidant properties could help prevent and minimize the lipid oxidation in food products, while maintaining nutritional quality and extending their shelf life [32]. Antioxidants can also be used for nuts, butter, fresh meat, meat derivatives, bakery products, fruits, and vegetables [26]. Moreover, an antioxidant layer may be utilized in combination with plastic materials to reduce the oxygen content dissolved in the beverage and by also limiting oxygen ingress and increasing the shelf-life [33,34]. At the same time, PET packaging with improved UV-light barrier properties helps to preserve the shelf life of light sensitive products (e.g., dairy products, nuts, meat products, and wine), avoiding colour changes, flavors, and aroma degradation [35].

Antimicrobial packaging is another example of active agents in thin polymeric films to counter the growth of pathogens and ensure the safety of consumers [22]. For instance, the addition of essential oils with antimicrobial actions into transparent plastic films can extend the shelf life of various perishable goods. Tests showed that the packaging prevented the growth of mould in bread for at least 3 weeks, expanded the sealing quality of fresh cherries by 40%, and extended the shelf life of cheddar cheese by 50% [36]. Indeed, oregano and rosemary extracts showed antioxidant and antimicrobial effects, and increased the display life of lamb meat without any colour and flavour changes for 8-13 days compared to control samples [37]. The extension of the shelf-life and the reduction of possible microbiological risks for salads and fresh salmon filets was also respectively confirmed by Muriel-Galet et al., (2013) and Rollini et al., (2016) [38]. Furthermore, active packaging can also release desired compounds in order to decrease the deterioration effects of the food inside the package [22,34]. Indeed, carbon dioxide (CO2) is commonly added to suppress the microbial growth in certain products such as fresh meat, poultry, fish, cheese, and baked goods [21,39] and to reduce the respiration rate of fresh produce [21,40].

Finally, active packaging plays an important role in protecting the specific aroma of foods by removing unwanted odors and flavours such as, the Cryovac Freshness Plus Odour Scavenging system that has been targeted at the processed cheese and meat market [41]. Many other studies can be found regarding the application of active packaging in the F&D industry. Table 1 summarizes the principal applications of this technology for five different mainstream products.

Table 1. Some applications of active packaging technologies

Active Packaging Technologies	Bakery goods	Dairy products	Fruit and vegetables	Meat and fish	Wine	References
Antimicrobial packaging	X	X	X	X		30,36-38

Antioxidant packaging	X	X	X	X	X	6,21,26,30,33,34
Carbon dioxide releasers	X	X	X	X		21,30,39,40
Ethylene scavengers			X			21,26,27,30
Improved UV-light barrier		X		X	X	35
Moisture scavengers	X	X	X	X		6,21,28,29
Odours and flavour scavengers		X		X	X	22,30,41
Oxygen scavengers	X	X	X	X		6,21,26,30

2.2 Intelligent packaging

The EU Regulation 450/2009/EC defines intelligent materials as: "materials which monitor the condition of packaged food or the environment surrounding the food" [16]. Intelligent packaging is also defined as the: "system that provides the user with information on the conditions of the food and should not release its constituents into the food" [17]. In contrast with active packaging, intelligent packaging systems should in no way release chemicals into the packaged food [16]. Indeed, an intelligent system is attached outside of the package and it is separated from food by a functional barrier, which prevents the migration of substances into the food [16,17]. Intelligent packaging is able to sense, monitor the conditions of packaged food and to give information about food quality and safety to manufacturer, retailer and consumer [6,42,43]. Therefore, this technology could help in minimizing waste, reducing the risk of throwing away foods that are still edible [23,44]. For instance, factors that contribute to FW include the confusion over "use-by" and "best-before" dates. Unawareness of the correct meaning of these terms results in edible products being thrown away at retailers, food services, and at consumers' levels [23].

Thus, food quality could be attained using freshness indicators able to sense microbial growth or chemical alteration inside the food product [22]. The underlying concept is that microbial growth is the cause of irreversible changes such as a variation in pH, which determines food spoilage [42]. Freshness indicators working based on colorimetric approaches detect an increase in pH by reacting with the volatile amines formed [22]. Another evidence of food spoilage is the production of CO_2 in meat products, fresh fruits, and fresh cut-vegetables [22,42]. With an increase in CO_2 concentration, freshness indicators used in the form of labels show an increased colour change from yellow-green to orange [45]. The ripeSense® indicator is another intelligent tool which can indicate the quality and freshness of foods [42]. It is the world's first intelligent label that changes colour to indicate the ripeness rate of fruit. It works by reacting to the aromas released by the fruit as it ripens. The freshness indicator initially is red, graduates to orange, and finally yellow [46].

Moreover, considering that time to storage and fluctuation in temperature are common reasons for food spoilage, several studies pointed out that Time-Temperature Indicators (TTIs) significantly help in monitoring changes in food attributes [22,42,47]. TTI can give a solution for maintaining the cold chain and can be an important action point to reduce FW [48,49]. Essentially, TTIs are labels that undergo an irreversible change in colour when food or drinks are exposed to a temperature exceeding the critical one [47,50]. For instance, the Keep-it® indicator constantly monitors temperature over time and shows the actual remaining shelf life of a product. When the dark stripe on the indicator is equal or is less than zero, the food is no longer edible (http://keep-it.com). It is an economical device that can help to control the quality of perishable foods such as dairy products, seafood, frozen and chilled meat [42]. Other examples of TTIs available on the market are 3M MonitorMarkTM, Check-Point®, and OnVu® [42,49].

Moreover, temperature indicator (TI) is able to inform consumers when the product has the right temperature to be drunk or eaten. For instance, the thermographic label shows when the Matua wine is ready to be drunk (www.matua.co.nz). Other examples of TI are the Coca-Cola Turkey and Coors Light aluminium cans, where the thermo-chromic ink design will be visible only when the cans are chilled [51]. The BlindSpotz™ cold chain sensor is another example of TI for meat products and fresh lettuce [52].

The leakage indicator, instead, monitors the integrity of the package and informs on whether the package has been delivered without being damaged through the packaging, storage, distribution, and retailing stages of the FSC [22,42]. Indeed, defects in packaging can affect the quality of foods and can also result in variations in optimal concentration of gases like O_2 and CO_2 that could be attained using gas sensors like Ageless Eye® [22]. Furthermore, gas sensors were also developed for the detection of beverage contaminants, such as allergens, and adulterants [10].

Finally, several studies can be found regarding the application of intelligent packaging in the F&D Industry. Table 2 summarizes the principal applications of this technology for five different mainstream products.

Table 2. Some applications of intelligent packaging technologies

Intelligent Packaging Technologies	Bakery goods	Dairy products	Fruit and vegetables	Meat and fish	Wine	References
Freshness indicator		X	X	X		22,42,45
Gas sensor		X	X	X	X	10,42
Leak indicator				X		22,42
Time-Temperature Indicator (TTI)	X	X	X	X		21,42,47,50
Temperature Indicator (TI)			X	X	X	42,51

3. Eco innovations: compostable packaging

According to the EN 13432 standard, "Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging", the compostability is the characteristic of a material to turn into compost within 3 months by the industrial composting process [53,54].

Compostable packaging could be made from petrochemical materials [e.g., Poly (butylene adipate-co-terephthalate) (PBAT), Polycaprolactone (PCL)], partly bio-based (e.g., starch blends) or by completely bio-based materials [e.g., Polylactic acid (PLA), Polyhydroxyalkanoates (PHA)] [54,55]. Bio-based products are defined in the European standard EN 16575 as "derived from biomass". Despite the biological origin, bio-based products are not always intrinsically "renewable". According to Van den Oever (2017), bio-based feedstock can be called renewable as long as new crop cultivation balances harvesting [54]. The renewable feedstocks could be derived from plants that are rich in carbohydrates (e.g., corn, sugar cane), plants that are not eligible for the food or feed production, and from organic waste feedstocks [56].

Biopolymers' production is an option with a growing interest in the packaging sector [57]. In 2020, global production capacities of bioplastics amounted to about 2.11 Mt with almost 47% (0.99 Mt) of the volume destined for the packaging market [58]. Indeed, for almost every conventional plastic material and application, there is a bioplastic alternative available on the market that has the same properties and potentially offers additional advantages [56].

In this context, a broad spectrum of these products is available for the F&D industry. Due to this, companies are starting to introduce eco-innovation into the market. For example, Sarchio® pasta launched the new packaging in PLA [59] as well as Nonno Nanni® made the stracchino's package completely compostable. This last is made from the use of agro-industrial residues [60]. Moreover, Almaverde Bio ® frozen food packages are Ok Compost certified in accordance with the EN 13432 [61] as well as the new packaging for meat launched by Fileni® [62]. Finally, a British designer created the "Greenbottle" that is a paper wine bottle completely compostable [63].

Furthermore, compostable packaging could also be obtained from the use of organic waste coming from the production and/or transformation process of the F&D industry. In this regard, there is a particular emphasis on recovering, recycling, and exploiting industrial waste. F&D manufacturers could reduce the high costs of the treatment and the final disposal of solid and liquid waste [64]. For instance, it is well known that the dairy industries generate large volumes of liquid waste (milk or cheese whey) as a by-product during coagulation of the casein process [65]. Its disposal poses the most critical pollution problem in the dairy industry, considering that it represents 85%-95% of the original milk volume, and contains about 55% of the whole milk nutrients [66]. Furthermore, a vast amount of evidence points out the possibility to use the cheese whey for the production of biopolymers such as, PHB (Polyhydroxybutyrate) [67,68,69]. The PHB material could be used to produce economic and competitive packages for dairy products [69]. Moreover, WHEYLAYER-based films were validated for storing various foodstuffs such as, sausage, cheese, and fresh pasta [67]. Furthermore, considering the large amounts of solid organic waste generated by the wine sector (e.g., skins of grapes), this beverage industry seems to be most sensitive to the ability to reuse process waste to reduce their disposal costs [70]. In this context, Naturally Clicquot is the first ever Champagne secondary packaging produced from the skins of the grapes [71]. However, strides are yet to be made in the research and development of primary packaging for wine made from the solid wastes of the winery industry. Other evidence pointed out that compostable packaging can also be made from peels of tomatoes [72], green peas, red lentils [73], peals and pulses discarded during the production phase, and unsold artichokes [74]. Finally, chitosan is another by-product of the food industries that, due to its low toxicity, biodegradability, stability and relatively low cost, is suitable for the production of compostable packaging. Chitosan films have good mechanical and antimicrobial properties and moderate permeability to gasses (CO_2 and O_2) [75,76]. Furthermore, they have antioxidant and antibacterial properties able to prevent food spoilage and extend food shelf life [77,78].

Table 3 highlights the references found as examples of compostable packaging' applications for five different mainstream products.

Table 3. Some applications of compostable packaging.

Compostable packaging	Bakery goods	Dairy products	Fruit and vegetables	Meat and fish	Wine
Plant-based	59	60	61	62	63
FLW-based	70,74	67-69	74,78	70,77	

4. Conclusions

Nanotechnology applications in food packaging could help to meet the global challenge to reduce food loss and waste by enhancing food's shelf-life and improving the communication functions of the packages. These advancements will positively affect consumers by increasing food safety as well as all the actors of the food supply chain by maximizing the efficiency in the use of the resources. Moreover, the development of biobased packaging materials will also generate new opportunities into the packaging market reducing the environmental impact without giving up the necessary mechanical and barrier properties of the common alternatives. However, more research is needed for the concrete development of sustainable food packaging made from organic waste feedstocks.

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Chapter 2

HEALTH AND ECO INNOVATIONS IN FOOD PACKAGING: A LITERATURE REVIEW

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Abstract: Innovative packaging solutions such as smart and sustainable packaging, are introduced in the market to satisfy the consumer demand for healthy and environmentally sustainable food products. Consumer acceptance and willingness to pay for such packages are key factors for their successful commercialization. The aim of this study is to investigate and identify patterns of consumer's acceptance and willingness to pay (WTP) for smart and sustainable packages by collecting evidence available in the literature and published between 2005 to 2018. Results show that consumers acceptance and WTP for smart packaging are influenced by the consumers knowledge about these technologies. Also, consumers accept and are willing to use sustainable packages to protect the environment regardless of the match between the food product and the packaging material. Instead, consumers' WTP for sustainable packages largely depends on the healthiness perception of the food product.

Keywords: smart packaging, sustainable packaging, consumer acceptance, willingness to pay.

1. Introduction

Consumer demand for healthy and environmentally sustainable food products led food companies to develop innovative packaging with food safety enhanced level, improved traceability features, extended shelf-life properties as well as made with environmentally sustainable materials [1]. Active packaging refers to the incorporation of chemicals into packaging material to improve food quality and safety and therefore extending the shelf-life [2,3]. The intelligent package, instead, allows monitoring of food products' quality through the packaging as it reacts with the surrounding environment during transportation and storage phases displaying the quality level of the product when the product reaches the consumer [4]. Further, other technological innovations in the packaging area mainly focus on developing new materials to create sustainable packaging which minimize the plastic waste and their environmental impact [5]. However, innovations in the food sector, including packaging materials, are successful only if accepted by consumers [6]. Understanding consumer acceptance and willingness to pay may guide firms' investment towards those packaging innovations that are more likely to succeed in the market. Then, the objective of this research is to summarize the evidence from studies investigating consumer's acceptance and willingness to pay for food products packaged with innovative technologies (active and intelligent packaging, sustainable packaging), in order to support food companies' investment decisions.

2. Methodology

This research reviews the literature on consumer acceptance and willingness to pay for innovative food packaging solutions, collecting the evidence from articles published in scientific journals between 2005 to 2018. The literature selection was performed in three steps following a detailed protocol for selecting the evidence available in the literature. The protocol allows a transparent and replicable paper selection process. In the first step, search terms as: consumer OR consumers AND food AND package OR packages AND health OR healthy OR sustainable OR eco-friendly OR eco-friendly OR "environmental sustainable" OR "environmental sustainability" were selected for the identification of research studies. The search process was performed using two search engines, Scopus and ScienceDirect. At this stage, 712 papers were retained. In the second step exclusions and inclusion criteria were applied. Papers selected were studies written in English and published between 2005 to 2018. Reviews, conference papers and papers written in other languages were excluded. At this stage 499 papers were retained, 304 from Scopus and 195 from ScienceDirect. In the third, and last step, analyzing the information contained in the title of 499 papers retained from the second step, 70 papers were selected for being reviewed (42 identified via Scopus and 28 via ScienceDirect). Then, duplicate papers were removed (11) and the abstract and the text of remaining articles was analyzed. Thus, the final sample of papers systematically reviewed was composed of 19 articles listed in Table 1.

Table 1. Paper selected systematically reviewed

Authors	*Title*	*Journal*
Barska and Wyrwa, 2016	Consumer Perception of Active Intelligent Food Packaging	Problems of Agriculture Economics
Bieberstein et al., 2012	Consumer choices for nano-food and nano-packaging in France and Germany	European Review of Agricultural Economics
Cho and Baskin, 2018	It's a match when green meets healthy in sustainability labelling	Journal of Business Research
Erdem, 2015	Consumers' preferences for nanotechnology in food packaging: a discrete choice experiment	Journal of Agriculture Economics
Koenig-Lewis et al., 2014	Consumer's evaluations of ecological packaging – Rational and emotional approaches	Journal of Environmental Psychology
Macroubie, 2006	Nanotechnology: public concerns, reasoning and trust in government	Public Understanding of Science

Magnier and Crié, 2015	Communicating packaging eco-friendliness: An exploration of consumer's perceptions of eco-designed packaging	International Journal of Retail & Distribution Management
Magnier and Schoormans, 2015	Consumer reactions to sustainable packaging: The interplay of visual appearance, verbal claim and environmental concern	Journal of Environmental Psychology
Magnier et al., 2016	Judging a product by its cover: Packaging sustainability and perceptions of quality in food products	Food Quality and Preference
Muratore and Zarbà, 2011	Role and function of food packaging: What consumers prefer	Italian Journal of Food Science
O'Callaghan and Kerry, 2016	Consumer attitudes towards the application of smart packaging technologies to cheese products	Food Packaging and Shelf life
Rokka and Uusitalo, 2008	Preference for green packaging in consumer product choice – Do consumer care?	International Journal of Consumer Studies
Siegrist et al., 2007a	Lay people's and Expert's Perception of Nanotechnology Hazards	Risk Analysis
Siegrist et al., 2007b	Public acceptance of nanotechnology foods and food packaging: The influence of affect and trust	Appetite
Siegrist et al., 2008	Perceived risks and perceived benefits of different nanotechnology foods and nanotechnology food packaging	Appetite
Stampfli et al., 2010	Acceptance of nanotechnology in food and food packaging: a path model analysis	Journal of Risk Research
Tamani et al., 2015	An argumentation system for eco-efficient packaging material selection	Computers and Electronics in Agriculture
Wei et al., 2018	Consumer inferences of Corporate Social responsibility (CSR) claims on packaged foods	Journal of Business Research
Zhou and Hu, 2018	Public acceptance of and willingness-to-pay for nanofoods in the U.S.	Food Control

3. Results

Nineteen papers are included for the literature review. The studies selected are based on primary data. The number of respondents interviewed ranged from a sample of 46 respondents to a maximum of 1,131 respondents. The age of respondents ranges from a minimum of 18 years old to a maximum of 90 years old. Most of the studies were performed in European countries (Italy, France, Sweden, Poland, United Kingdom, Ireland, Germany, Hungary, Norway, Finland), instead, the remaining part from non-European ones (Switzerland, United States, Canada, and Malaysia).

3.1 Active and intelligent packaging

Results show that consumers are not familiar with nanotechnology applications on food packaging [7-10]. In general, consumers show a higher level of knowledge for "intelligent packaging" compared to "active packaging" [9,11]. Results show that consumers are willing to accept such packages whether they are used for extending product shelf-life or for informing about product quality level [9]. Consumers define intelligent packaging as "a good idea" to reduce food safety risk [12]. However, Zhou and Hu (2018) in a study on US consumers show that more than half of the respondents have a negative view of the use of nanotechnology in the food packaging due to the risk perception for human health [13]. From the analysis of aggregated data, Siegrist et al., (2008) pointed out that the consumer acceptance might be linked to the perceived risks towards these food packaging nanotechnology applications [14]. Therefore, if the perceived risk is lower the consumer acceptance is greater. Moreover, results show that nanotechnology applications are perceived differently. O'Callaghan and Kerry (2016) pointed out that intelligent packaging is most likely to be accepted as the consumer believes to have more control over such technology as well as believe that this technology does not interfere with the food product [9]. Findings show that perceived benefit is the most important predictor for consumer's willingness to buy (WTB) active and intelligent packaging. Therefore, consumer's WTB is greater if perceived benefits are greater [15,16]. The analysis of socio-demographic characteristics pointed out that consumer perception of benefits varies with age and gender; older respondents perceived more beneficial than younger respondents and females perceived significantly less benefits than males [14]. In the end, results show that the consumers' willingness to pay for food products packaged using nanotechnology-based materials is influenced by the level of information consumers have about the technology used [9]. Similar results are found by Barska and Wyrwa (2016) that found that the largest part of consumers familiar with active and intelligent packaging declared to be willing to purchase food packaged in such new packaging solutions, despite the higher prices [11]. At the same time, Erdem (2015) pointed out that consumers who are more concerned about the food risk are willing to pay approximately twice as much when nanosensors are present in the packaging [12]. Contrasting findings were found by Zhou and Hu (2018) that proved that consumers are willing to use a bottle produced with nanotechnology if a price discount is provided to them [13]. Finally, consumer's willingness to pay varies with the respondents' socio-demographic characteristics. Consumers between the ages of 18 and 34 are willing to pay more for that than older individuals and females are willing to pay more than male. Education did not affect consumers' WTP [9]. However, barriers to consumers acceptance for active and intelligent packaging has been indicated to be the high price for food products packed with these innovative packaging solutions compared to those packaged in conventional ones; the consumer skepticism as well as the lack of knowledge about such technologies; the consumers' habit to buy products in traditional packaging and, lastly, the consumers' perception of food safety risks due to the contact between the food product and these new technologies [11].

3.2 Sustainable packaging

Results show that, for a large part of consumers, the packaging material is an important product attribute in the consumer choice and people clearly prefer the environmental-friendly package alternative [17]. Consumers, regardless of the country of residence, are willing to use biodegradable and/or compostable packaging for protecting the environment [18]. Also, findings show that when the food product is packaged in a sustainable material the consumer perception of the overall quality of food product increases [19,20]. Moreover, the quality perception of food products rises to the maximum if the food product is considered intrinsically healthy (e.g., cereal bars) [21]. This result is also supported by Magnier et al., (2016) that found that the perceived quality is significantly higher when healthy products (e.g., raisins) are packaged in sustainable packaging [19]. Contrasting findings are shown by Magnier and Crié (2015) that pointed out a decrease in perceived quality due to hygiene sacrifice evoked by respondents in relation to the degradation or elimination of packaging [22]. Results show that perceived benefit is a predictor of the consumer's purchase intention [22,23]. Moreover, a higher concern for the environment leads to perceived more benefits associated with ecological packaging. Then, the environmental concern is a main factor in predicting consumer's purchase intention for sustainable packaging [23]. At the same time, the attractiveness of the packaging and the use of verbal sustainability claim positively influence consumer's purchase intention [24]. With reference to the consumer's willingness to pay (WTP) a premium price, results show that some consumers are willing to pay more for eco-friendly packaging [22] and WTP increases if the packaged product is perceived healthy such as bread and milk rather than sweets processed products such as ice creams and cookies [25]. Other consumers, instead, find it unacceptable to spend more for sustainable packaging [22]. However, a barrier to the development of sustainable packaging can be given by the skepticism shown by a part of the consumers about sustainability claims of new packaging materials as seen as a marketing tool employed by food companies to promote the sales of sustainable packaging for food products [21,22]. Others "perceived costs" are the less packaging attractiveness and the consumer's idea that ecological packaging might not protect the food product as a conventional package [22]. Studies analyzed do not reveal any role of socio-demographic variables on the consumer acceptance and willingness to pay premiums for food products packaged with sustainable packaging.

4. Conclusions

Consumer acceptance and willingness to pay for innovative food packaging are important factors for their commercialization. Studies on consumer attitudes towards the new generation of packaging represents a valuable source of information for food companies in order to design and market successfully new matches of packages and food products. Results suggest that consumers are willing to use active and intelligent packaging to reduce food safety risks and improve food quality. At the same time, sustainable packaging is highly accepted by the consumer for protecting the environment. The successful implementation and commercialization of these innovations depends on the development of policies to promote such packaging solutions in order to increase consumer's perceived benefits. Food companies could conduct a more intensive media promotion [11] in order to encourage consumer adoption. Much research has identified the necessary components of effective food risk communication [26-28].

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Chapter 3

INTENTION TO PURCHASE ACTIVE AND INTELLIGENT PACKAGING TO REDUCE HOUSEHOLD FOOD WASTE: EVIDENCE FROM ITALIAN CONSUMERS

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Abstract: Innovations in food packaging, such as active and intelligent ones, improve food safety and lower household food waste by extending product shelf-life and providing information about food quality, respectively. The consumer adoption of such innovations could contribute to reaching one of the Sustainable Development Goals which calls for halving the per capita global food waste by 2030. Thus, this paper aims to investigate the consumers' willingness to purchase active and intelligent packaging to reduce household food waste using a sample of 260 Italian consumers and a modified Theory of Planned Behavior (TPB) model. Using a structural equation model, findings show that respondents are more willing to purchase intelligent packaging rather than the active one to reduce their wastes at home. Finally, attitudes, perceived behavioral control, awareness as well as planning routines are the most important drivers of the intention to reduce household food waste.

Keywords: active packaging; intelligent packaging; household food waste; consumer's willingness to purchase.

1. Introduction

Ensuring food safety is an essential step to guarantee human health and to achieve food security [1] while, at the same time, it inevitably leads to the generation of food waste (FW) [2]. Thus, guaranteeing food safety may hinder the achievement of one of the Sustainable Development Goals (SDGs), adopted by the United Nations' 2030 Agenda, which is that of halving per capita global FW by 2030 [3-6]. However, new technology innovations, in the food package sector, are able to jointly ensure the safety of food, maintain the expected quality throughout the Food Supply Chain (FSC), as well as allow to lower the waste generated at household level by extending the product shelf-life or indicating the quality level of the food product supporting consumers in sustainable food choices [2,3,7]. Thus, the packaging, besides protecting and preserving the food content from contaminations of the external environment and from mechanical damage during transportation stages [8,9], plays a key role in preventing food spoilage, extending its shelf-life, and thus minimizing waste [10].

In industrial countries, where 99.8% of all foods and beverages items are sold packaged [11,12], improvement in packaging features could be a suitable solution to improve food safety and then to avoid FW [7,13]. In EU-28, around 88 million tons of FW, or 173 kg per capita, are generated annually and almost 53% occurs at the household level [14,15]. In Italy, the total amount of FW is estimated at approximately 20 million tons in 2006 resulting in approximately 146 kg per person of which 27.5 kg occurs at household level with associated total costs of €12.7 billion [16,17]. Foods which are more frequently wasted are mainly dairy products, eggs and meat (43%), followed by bread (22%) and fruit and vegetables (19%) [16].

The need to improve food safety and to reduce the amount of FW at final stages of the FSC, has led companies to develop innovative packaging solutions such as active and intelligent ones [7]. In detail, active packaging refers to substances added to polymer films or sachets inside the packaging that can absorb (scavengers) or release (emitters) gaseous matter [18,19]. Active packaging such as ethylene scavengers, oxygen scavengers, moisture absorbers, carbon dioxide emitters have the potential to extend food shelf-life while maintaining food quality [7,20,21]. Instead, intelligent packaging such as time-temperature indicators, freshness indicators, leak indicators provide information to manufacturer, retailer and consumer about food quality and safety based on the ability to test, detect or record external or internal changes in the product's environment [12,22-24]. This technology could help retailers and consumers to reduce waste minimizing the risk of foods still edible being thrown away [7,25]. Active and intelligent packaging are defined in Europe by the Regulation 450/2009/EC which integrated the Regulation 1935/2004/EC [26]. The European regulation states that the individual substances, or the combination of substances, used to make active and intelligent components should be subjected to the European Food Safety Authority (EFSA) authorization which performs the risk assessment of such substances. Also, the regulation requires that active and intelligent packaging should be labelled with the words "do not eat", allowing consumers the identification of non-edible parts [11,12,26]. Table 1 lists and describes the main active and intelligent packaging technologies already available on the market.

Table 1. Description of some active and intelligent packaging technologies.

Technology	Description	References
Active Packaging		
Antimicrobial packaging	Antimicrobial packaging systems have been manufactured in order to regulate the microorganisms that threaten to affect the quality and safety of food packages.	19,27
Antioxidant packaging	Antimicrobial packaging prevents the lipid oxidation that is the cause of food degradation thanks to the incorporation of antioxidant agents in thin polymeric films.	28,29

Ethylene scavengers	A range of different technologies that involve chemical reagents added to polymer films or sachets to absorb ethylene which is the cause of deterioration of fresh and minimally processed fruits and vegetables.	7,21,29
Moisture scavengers	Pads made from super-absorbent polymers, which absorb moisture maintaining conditions that are less favorable for the growth of microorganisms.	7
Odors and flavors scavengers	Active technology able to protect the specific aroma of foods by removing unwanted odors and flavors.	20,30
Oxygen scavengers	Sachets with active substances, generally in powder form, that is able to remove the oxygen from a closed package.	7
Intelligent Packaging		
Freshness indicator	Freshness indicator working based on a calorimetric approach provides information about food quality showing an intense colour change when it detects microbial growth or chemical alteration inside the food product.	19,23
Gas sensors	Gas sensors are intended to detect and indicate the presence of gaseous or volatile compounds (e.g., carbon dioxide, oxygen, volatile amines).	23
Leak indicator	Leak indicator monitors the integrity of the package to which it is attached.	31
Temperature indicator (TI)	TI informs the user when the product has the correct serving temperature to be drunk or eaten.	24
Time-temperature indicator (TTI)	TTI constantly monitors temperature over time and shows the actual remaining shelf life of a food product to which it is attached.	18,32

However, most of the technological research in the food area, including packaging, is consumer-driven meaning that innovations are successful only if accepted by consumers [33]. For instance, consumers willing to lower FW would also be more willing to accept and to purchase food products packaged in innovative solutions.

To the best of our knowledge, no studies on this topic are available. Then, the aim of this paper is to explore to what extent consumers willing to reduce FW are also willing to purchase products packaged with active and intelligent packaging to achieve their scope. Also, to assess which of these two packaging innovations is most preferred by consumers in order to support food companies to invest for that technological solution more likely to succeed into the market.

The next section outlines the literature review and the proposed empirical framework. Section 2 describes the data and the model used in this analysis. Section 3 presents the results that are then discussed in Section 4. Finally, Section 5 ends the papers with the conclusions based on the findings obtained in our study.

1.1 Literature review on individual driver of lower food waste and theoretical framework

Previous studies largely used the Theory of Planned Behavior (TPB) introduced by Ajzen (1991) to explain food consumption patterns as well as to analyze FW drivers [34]. Reviewed studies point out that not only individual attitude, subjective norm and perceived behavioral control but also individual awareness, food shopping routines, planning routines and ability to reuse food leftovers, are related to the individual willingness to reduce FW.

Attitude entails the extent to which the individual has a favorable or unfavorable evaluation of the behavior [34]. In the literature, negative attitudes toward FW, such as feeling bad or guilty about wasting food, has a significant role in the consumer intention to not waste food [35-37].

Subjective norms indicate the social pressure that the individual can perceive in performing or not a certain behavior [34]; individuals should intend to waste less food if their food wasteful behaviors are disapproved by other members in their personal networks [35,37-40].

Perceived behavioral control refers to the individual's perceived ability to perform a specific behavior, and thus to the extent to which the individual perceives the behavior to be easy or difficult to enact and be under his/her control [34]. In the literature, perceived behavioral control relates to the degree to which consumers think reducing FW is under their full control. It represents potential barriers or facilitators of conducting the behavior according to whether the subject perceives ease or difficulty to lower FW [35-37]. An Individual who declares to be able to lower household waste more likely than others will implement strategies to pursue such a goal, to lower FW.

Also, consumers' awareness regarding the amount and type of food they waste and its consequences from an economic and an environmental standpoint affect individual intention to lower FW [35,41]. Consumers that record a higher level of awareness about the negative effect of waste will be more likely to reduce household waste [35,36,39,42,43].

Furthermore, shopping and planning routines are recognized to be important in explaining consumer behavior related to household FW [35,40,44]. Negative shopping routines, such as purchasing too much food during shopping trips, could contribute to increased household waste [35,39,44]. Similarly, planning meals in advance or making the shopping list may contribute to a lower household FW [35,40,42,44,45]. Also, leftovers reuse routines could further contribute to lower household waste [35,44]. Therefore, good shopping, planning routines as well as good individual ability to reuse leftovers may positively impact on the consumers intention to reduce household waste.

These factors listed above that literature found affecting individual intention to reduce household FW may also relate with individual willingness to purchase active or intelligent packaging in attempting to further mitigate the household waste. Figure 1 shows the empirical link between the variables described above.

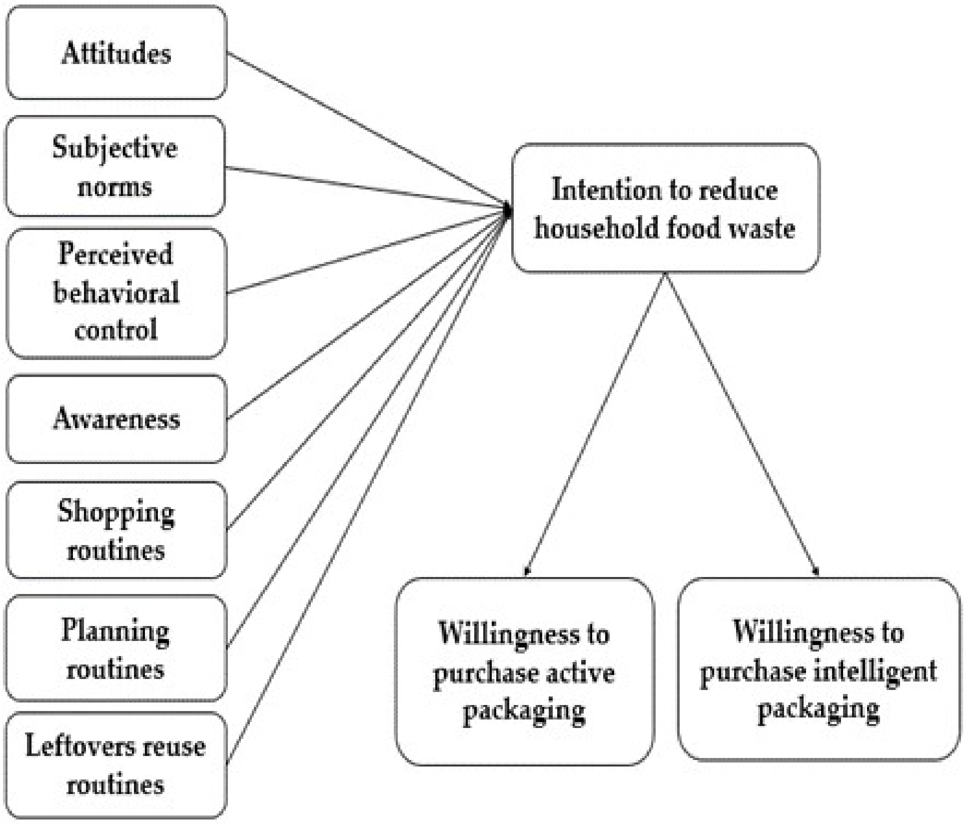

Figure 1. Determinants of intention to reduce household food waste and willingness to purchase active and intelligent packaging.

2. Materials and Methods

2.1 Participants and design

Data were collected by means of a web-based survey conducted in April 2020 in Italy. The survey collects information on Italians aged 18 years old and over, who are responsible for the food shopping in their household. Before starting the survey, a brief description of active and intelligent packaging was provided to respondents, as reported in Appendix A - Table 1. In this study we used a convenient sample composed by 260 respondents, which socio-demographics and economics characteristics are reported in Table 2.

Table 2. Socio-demographics characteristics of respondents (N=260).

Categorical variables	*Sample %*
Gender	
Male	30.4
Female	69.6
Education	
Primary school	0.4
Middle school	0.8
High school	32.3

Bachelor's degree	18.5
Master's degree	23.1
Postgraduate (e.g., PhD, master)	25
Occupation	
Not employed/student/housewife	46.9
Retired	0.8
Blue-collars	1.9
White-collars	31.2
Managers	6.5
Self-employed	12.7
Family monthly income	
Up to EUR 1,000	10.4
EUR 1,001–3,000	46.5
EUR 3,001-5,000	18.8
EUR 5,001-7,000	5.8
EUR 7,001 and over	18.5
Continuous variables	*Mean/SD/Range [min.-max.]*
Age	35.8 / 11.7 / [20 min. – 81 max.]
Household size	3.4 / 1.2 / [0 min. – 8 max.]
Number of children (under 14 years old)	0.4 / 0.7 / [0 min. – 4 max.]
Number of employed in family (excluding interviewed)	1.3 / 0.9 / [0 min. – 5 max.]

2.2. Measures

The questionnaire contained measures of attitudes towards food waste, subjective norms, perceived behavioral control, awareness of food waste consequences, food-related routines, intention to reduce household FW, willingness to purchase active and intelligent packaging and socio-demographics. Generally, respondents were asked to indicate their agreement or disagreement to some statements scored on a seven-point Likert item scale ranging from "totally disagree" (1) to "totally agree" (7).

Following the TPB (Ajzen, 1991), a measure of general attitudes toward FW was used, consisting in a single item scale: "Throwing away food is an irresponsible behavior".

Subjective norms were composed by 2-items scale: "Most people important to me disapprove of me throwing out some food" and "Wasting food makes me feel guilty (e.g., for people who do not have enough food, for the environment, for the waste of money)". These statements were developed in accordance with the TPB and with a prior literature on household FW [35,44].

Moreover, perceived behavioral control was assessed with 2-items scale: "Household food waste is avoidable" and "Reducing household food waste help in solving waste issues" [35,45,47].

Consumer's awareness of the economic, social and environmental consequences derived from the generation of household FW was measured with 2-items scale. The first one captured the economics' awareness and it was assessed with the following statement: "The amount of food waste generated at home is a significant waste of money". It was formulated in compliance with prior FW literature [35,41,44]. The second item, related to the consumer's awareness of social and environmental issues, was verified as follows: "The amount of food waste generated at home is a very important social and environmental problem" [47].

Shopping routines were measured with a 3-items scale referred to buying more food than necessary: "I often buy unintended food products when shopping", "I often buy food in packages that are too big for my household's needs" and "I usually buy higher amounts of food when there are special offers". Planning routines were, instead, assessed with a 2-items scale related to shopping and meals: "The shopping trips are usually planned in advance (e.g., shopping lists are made)" and "The home meals are usually planned before going to the grocery store". Finally, routines related to leftovers were identified with a single item scale about the storage of leftovers, as follows: "The leftovers are stored in appropriate conditions so they will be consumed later". All these items related to shopping routines, planning routines and leftovers reuse routines were developed by the authors based on previous studies of consumer FW [35,44].

The intention to reduce household FW was measured using 3-items scale: "I am not interested in reducing household food waste and I have not planned to reduce it in the next month", "I am interested in reducing household food waste and I have planned to do so in the next month" and "I am interested in reducing household food waste and I have already started to do so in the last month" [48].

Finally, to measure the willingness to purchase active and intelligent packaging, respondents were asked to indicate their intentions, with a 7-point Likert item scale ranging from "totally not willing" (1) to "totally willing" (7), related to these two statements: "Are you willing to purchase food products packed with active packaging?" and "Are you willing to purchase food products packed with intelligent packaging?". Lastly, the mean value was calculated for the elements of TPB measured by using multiple items scale as shown in Appendix A – Table 2. The latter also shows the correlations between all the variables considered in the proposed empirical framework.

2.3 Estimation Method

The model in Figure 1 has been estimated using structural equation modeling (SEM) which simultaneously includes measurement and structural parameters in a full latent variable model approach. The measurement model is related to the within-construct relationship, which regards the relation among measured variables, such as item scale, and related latent construct. The structural model allows to assess the magnitude and direction of the relations among the set of measured constructs and used to verify whether the hypothesized relationships take place in the tested model. In our model, the correlation matrix between factors, reported in Appendix A - Table 2, was used as an input to estimate the structural coefficients between constructs and latent variables [49]. The SEM models' goodness of fit was estimated using a chi-square test and recommended incremental goodness-of-fit indices: the root mean square error of approximation (RMSEA), the comparative fit index (CFI) and the Tucker-Lewis Index (TLI). The not statistically significant value for the chi-square test indicated that the model fits well the data [50]. CFI and TLI values of approximately 0.90 are widely considered acceptable values of the goodness of fit [51,52]. RMSEA value of 0.05 or less indicates a good fit and values up to

0.08 represent errors that approximate those expected in the population [53,54]. The model was estimated using STATA 14.0 software.

3. Results

The results of testing the conceptual models are presented in Table 3. The models converged well and had satisfactory goodness-of-fit. In detail, the goodness-of-fit indicators were extremely close to the strictest threshold value of 0.90 for CFI and TLI and equal to the cut-off point of 0.05 for RMSEA. Overall, explained variances were 69.20% and 76.60% for willingness to purchase active and intelligent packaging, respectively.

Table 3. The structural model of intention to reduce household food waste and willingness to purchase active and intelligent packaging.

Parameters	**Willingness to purchase active packaging**	**Willingness to purchase intelligent packaging**
	Coefficient	*Coefficient*
Intention to reduce household food waste	0.679***	0.812***
	Intention to reduce household food waste	Intention to reduce household food waste
Attitudes	0.400***	0.384***
Subjective norms	0.018	0.021
Perceived behavioral control	0.295**	0.327*
Awareness	0.218*	0.239**
Shopping routines	0.118	0.127
Planning routines	0.167***	0.175**
Leftovers reuse routines	0.094	0.109
Indexes of goodness-of-fit		
R^2	69.20%	76.60%
Likelihood Ratio χ 2 (6)	29.7 p-value <0.001	34.7 p-value <0.001
RMSEA	0.05	0.05
CFI	0.91	0.96
TLI	0.90	0.95

Note: *, ** and *** indicate 10, 5, and 1 percent significance levels, respectively; Likelihood Ratio test p-value equal to 0.10.

Results from both models, in the second row of Table 3, showed that individual intention to reduce household FW was a good predictor of the willingness to purchase active and intelligent packaging. Also, we performed the Likelihood Ratio test (LR), which provided us a p-value equal to 0.10, rejecting the null hypothesis that one model performs better than two separate models with the 10% significance level. The p-value of 0.10, at the limit of being statistically significant, may indicate that respondents in our sample do not clearly distinguish the difference between the two packages tested. However, respondents aiming to reduce their wastes at home were more willing to purchase the intelligent technological solution rather than the active one as pointed out from the magnitude of the coefficients in the second row of Table 3. The estimated parameter sizing the association between intention to reduce waste and willingness to purchase intelligent packaging was equal to 0.812 ($p < 0.001$) and larger than that for the willingness to purchase active packaging that was equal to 0.679 ($p < 0.001$) to achieve lower household FW. Also, we performed a coefficient equality test assessing whether the parameter 0.812 was statistically different from 0.679. The statistic for the equality test was $F (2, 256) = 3.555$ with $Prob > F$ 0.03. Thus, we reject the null hypothesis that the two coefficients were statistically equal at 5% of the significance level. Such a result was consistent with the summary statistics reported in Table 2 in Appendix A, second column, reporting the mean value for the intention to buy intelligent packaging (6.29) higher than that for the intention to buy active packaging (5.81). Also, in this case, we performed the paired means t-test to analyze whether the means were statistically different (6.29 vs. 5.81). The p-value for the test was equal to 0.0000401, statistically significant at 0.01% level. Then, we rejected the null hypothesis of mean equality.

Concerning the determinants of the intention to reduce the household FW, four out of the seven individual-related variables assessed in our conceptual models, and selected according to the literature, showed a positive and significant effect on the individual's intention to lower FW at the household level. In both models, attitude towards FW was the strongest predictor of the intention to reduce wastes at home (0.400 and 0.384; $p < 0.001$). Then, the individual perceived behavioral control was the second most important individual-related factor driving consumers' intention to lower FW with positive and significant coefficients equal to 0.295 ($p < 0.05$) and 0.327 ($p < 0.01$) in both models. The intention to reduce household FW was also determined by the awareness about social and environmental issues related to FW, with magnitude of the coefficients equal to 0.218 ($p < 0.01$) and 0.239 ($p < 0.05$). Lastly, concerning the variables related to the household food management, the individual ability to plan food routine was the only individual-related factor that was positively and statistically significantly associated with the individual intention to lower household FW, with coefficients equal to 0.167 ($p < 0.001$) and 0.175 ($p < 0.05$) in the two models estimated. Instead, subjective norms, shopping routines, and leftovers reuse routines were not significantly related to the intention to reduce household FW in our sample.

4. Discussions

The present study explored to what extent consumers' willingness to purchase active and intelligent packaging is associated with their intention to reduce household FW. Results pointed out that consumers are more willing to purchase intelligent packaging rather than active packaging to reduce their wastes generated at home, thanks to the ability of this package to provide real-time use-by or expiration data. Indeed, recent findings suggest that consumers see the package as a tool to protect the food from damage, keeping it safe and with extended shelf life [55]. Also, consistent with previous studies, consumers are more likely to accept intelligent packaging over active packaging since they are often concerned about the toxicity of active substances added to polymer films, as well as scared about the accidental ingestion of active sachets, or whether their content gets disintegrated in handling the product [56–58]. Instead, in the case of intelligent packaging, studies found it most likely to be accepted as consumers believe that they have more control over such type of packaging and that it does not interfere with the food product and thus with human health [59]. This finding was also supported by a recent study by Tiekstra et al. (2021), who interviewed 1249 individuals from 16 European countries, showing that active packaging proved more difficult, rather than the intelligent one, to be successful in the market due to lower consumer acceptance of this technology [60]. Besides that, it is worth saying that consumers, on average, have a lack of knowledge regarding active and intelligent packaging and are unfamiliar with the technologies used to produce such packages. Indeed, a recent study by O'Callaghan and Kerry (2016), exploring consumer behavior towards emerging food packaging technologies, in a sample of consumers from 33 different countries, found a general lack of consumer knowledge/familiarity regarding active and intelligent packages which led to a low level of acceptance to such packages [59]. This would work as barriers for active and intelligent packaging adoption, which were mitigated after providing general information about the use of these food packaging solutions [59,61–63].

Furthermore, in this study, we investigated which factors are able to explain the intention to reduce household FW. Then, we mainly relied on the TPB and we also added several constructs from the literature that appeared relevant in explaining food-related behavior. Overall, our findings showed that the TPB explained very well the consumer's intention to reduce household FW. Specifically, attitude towards FW was found to be the main predictor of individual intention according to our estimates. This result finds support in the majority of studies on consumer and FW-related behavior. In detail, attitude toward the behavior reflects the personal positive or negative evaluation of performing that specific behavior. According to Stancu et al. (2016) and Visschers et al. (2016), the more negative the attitude toward FW, the stronger the personal intention to reduce the amount of household FW [35,37]. In other words, the more consumers were opposed to wasting food and were concerned about this issue, the more they were willing to lower wastes at home.

In addition, perceived behavioral control emerged in our study as the second most important driver of the intention to reduce household FW. Generally, individuals are more likely to engage in a specific behavior that is considered to be achievable [34]. Thus, consumers may be very willing to waste less food if they believe they are capable of modifying their behavior related to FW. This positive and significant relationship between perceived behavioral control and the behavior in question was revealed by many other studies using the TPB [37,44,64].

However, in our study, subjective norms did not appear significantly related to the consumer's intention to reduce household FW. Subjective norms concerning the social pressure to engage in a specific behavior were also found to be a weak predictor of individuals' intentions in other studies [35,37,45,64]. It could mean that what relatives and friends think about the importance of reducing wastes at home is not as strong in predicting the individuals' intentions as what respondents personally think about this type of behavior [35,37]. Indeed, taking into account the sociodemographic characteristics of our sample (Table 2), respondents have a medium-high education level, meaning that they are intrinsically motivated by the importance of lowering household FW. Then, regardless of what others think about the behavior in question, respondents are personally intending to lower the amount of household FW.

Furthermore, results from our study showed that people who are aware of the FW issue are more likely to avoid wasting food. Then, people with high environmental and social consciousness related to FW are more willing to engage in this behavior. This result was also supported by Principato et al. (2015), who, during a study on 233 Italian consumers, found that the greater the level of concern about the FW issue, the greater the intention to reduce waste at the household level [36].

Finally, several constructs such as shopping routines, planning routines, and leftover reuse routines were added to the conceptual model because they are considered significant, based on previous studies present in the literature, in predicting food-related behavior [35,39,40,44]. However, our results showed that only planning routines are relevant in explaining the consumer's intention to reduce household FW. This result was supported by several studies demonstrating that planning routines like meal planning and making shopping lists play an important role in avoiding unplanned purchases and then minimizing wastes at home [39,65]. Indeed, buying more food than needed increases the probability of food spoilage [40,45,66]. This emphasizes the importance of checking what foods are available in the fridge before going shopping and then planning meals, as well as making a shopping list, in order to avoid household FW.

5. Conclusions

The current work sheds light on the positive relationship existing between consumers' intention to reduce FW and their willingness to use active and intelligent packaging to achieve this goal. Such innovative packaging solutions, by extending food products' shelf life (active packages) or making consumers aware that food is nearing the expiry date (intelligent packages), promote food waste reduction at the household level. Also, the individual intention of reducing FW is driven by consumers' own attitudes to consider generating FW as irresponsible behavior, as well as by the perceived control over their own actions, the level of awareness about the negative impact of wasting food on the environment, the society, and the economy, and lastly, by their own ability to plan meals and to make shopping lists.

These results come with relevant policy and marketing implications. Policymakers and companies may develop informational campaigns to raise the level of consumers' knowledge about these technological solutions to encourage their acceptance and adoption among consumers. Furthermore, policies such as informational and educational campaigns should also be focused on raising awareness about negative effects of FW among consumers, which may have an important role in supporting intentional and behavior changes (e.g., providing recommendations and practical tips to cut wastes at the household level, for instance, by planning portions/meals and not cooking more than needed). Additionally, policymakers may also promote the use of positive messages to increase individual intentions to lower FW. Such messages should point out other benefits of saving food (e.g., saving money, time, etc.) over messages highlighting the negative social and environmental impacts of FW. This will offer a holistic view of multiple benefits arising from consumers' behavioral change.

Finally, some potential limitations should be taken into account in assessing our results. First, given the small sample size, caution must be used in assessing our results as they might not be transferable to the Italian population and cannot be generalized in other geographical contexts. Also, in our sample, two out of three respondents have a high level of education, which may significantly affect the consumers' awareness of FW as well as their attitudes and subjective norms related to individual intention to lower the household FW.

Second, the drivers affecting individual intention to reduce FW may be incomplete as contextual factors such as economic, sociocultural, industrial-productive, and environmental aspects of the country where individuals live also played an important role interacting with their own intention to reduce FW. Another factor that could also be taken into account for further research could be the personal direct or indirect exposure to chronic disease that could affect the individual's intention to adopt a particular behavior able to minimize risks for human health. Therefore, addressing our research question by using the TPB could be considered as another limitation of the study as it does not take into account environmental or economic factors that may influence the personal intention to perform a behavior, as well as the role of the individuals' emotions and unconscious stimuli during the decision-making process.

Finally, the study used self-declared intention to reduce household FW without observing a behavioral outcome (e.g., the actual amount of waste generated at home). Thus, future research will be aimed to fill these limitations listed above using a larger and more representative sample of the Italian population, accounting for contextual factors that may play a role in FW generation (e.g., by using recent empirical approaches based on nudging theory) as well as by attempting to use a behavioral outcome to measure wastes generated at home.

Appendix A

Table 1. General information about active and intelligent packaging.

Technology	Description
Active Packaging	The Regulation 450/2009/EC defines active materials as: "materials that are intended to extend the shelf-life of foods and to maintain or improve the condition of packaged food. They are designed to deliberately incorporate components that may release substances into the packaged food or the surrounding environment or absorb some substances from food or the environment". Therefore, active packaging refers to substances added to polymer films or sachets inside the packaging that can absorb (scavengers) or release (emitters) gaseous matter (e.g., ethylene, oxygen, moisture, carbon dioxide).
Intelligent Packaging	The Regulation 450/2009/EC defines intelligent materials as: "materials which monitor the condition of packaged food or the environment surrounding the food". Therefore, intelligent packaging provides information to manufacturer, retailer and consumer about food quality and safety based on the ability to test, detect or record external or internal changes in the product's environment.

Table 2. Descriptive statistics and correlations (N=260).

Variables	*Mean*	*S.D.*	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. Intention to reduce household FW	4.6	0.87	1									
2. Attitudes	6.72	0.7	0.26**	1								
3. Subjective norms	6.27	0.95	0.18**	0.43**	1							
4. Perceived behavioral control	6.23	0.94	0.30**	0.47**	0.35**	1						
5. Awareness	6.37	0.86	0.23**	0.48**	0.34**	0.50**	1					
6. Shopping routines	3.57	1.34	-0.06	-0.00	-0.02	-0.08	-0.08	1				
7. Planning routines	5.2	1.45	0.14*	0.20**	0.14*	0.20**	0.19**	-0.4	1			
8. Leftovers reuse routines	5.63	1.65	0.15**	0.28**	0.12*	0.13*	0.14*	-0.13*	0.02	1		
9. Willing to purchase active packaging	5.81	1.38	0.11*	0.13*	0.00	0.08	0.11*	0.15*	0.09	-0.04	1	
10.Willing to purchase intelligent packaging	6.29	1.02	0.15**	0.24**	0.13*	0.34**	0.20**	0.04	0.10	0.00	0.47**	1

Note: * and ** indicate 5 and 1 per cent significant levels, respectively.

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Chapter 4

INTENTION TO PURCHASE MILK PACKAGED IN BIODEGRADABLE PACKAGING: EVIDENCE FROM ITALIAN CONSUMERS

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Abstract: The dairy industry generates large volumes of liquid wastes that can be used to produce biopolymers, potentially employable for the creation of milk biodegradable bottles. In this regard, the paper aims to explore the consumers' intention to purchase sustainable packages, as well as to assess the willingness to pay for it considering renewable packages made using organic waste feedstocks from the dairy industry (e.g., whey) and plant-based material (e.g., corn, sugarcane, etc.). To reach the stated objectives, we collected individual-level information (e.g., age, gender, education, income) from a convenient sample of 260 Italian consumers and an extended version of the Theory of Planned Behavior estimated using a structural equation model. Findings show that attitudes and perceived behavioral control are the most important drivers of the consumers' intention to purchase sustainable packages. Finally, descriptive statistics show that respondents slightly prefer to purchase products packaged using plant-based biodegradable material as well as most of the respondents are willing to pay from 1% to 5% more for milk packed in biodegradable packaging, regardless of the raw material used.

Keywords: sustainable packaging; biodegradable; milk; whey; consumer's intention to purchase; consumer's willingness to pay.

1. Introduction

Dairy supply chain annually produces milk products for approximately 6 billion people worldwide, resulting in one of the most important sectors in the food industry [1]. Nowadays, the Europeans have one of the highest per capita consumption of dairy products worldwide, with an average higher than 150 kg per year [1,2]. In the last three decades, milk production has increased by more than 59% reaching 852 Mt in 2019 [1,3] as well as it is expected to grow by more than 15 Mt per year, by 2030 [4] spurred by the population growth and the rising consumption in developing countries [4-6]. According to the International Farm Comparison Network (IFCN) (2018), 1.2 billion more consumers will demand milk products by 2030 [6].

Despite widespread consumption, worldwide 20% of milk products produced annually are lost or wasted along the whole food supply chain (FSC) [7]. In industrial countries, most of this waste occurs at the consumption level [7,8], as well as at the manufacturing stage [9,10] in which about 90% of the milk used for cheese making ends up as whey that represents the main by-product in the liquid wastes generated from the cheese production [8,11,12]

The European annual production of whey is estimated to be equal to around 50 Mt and 40% of this amount continues to be discarded [9,12]. Its disposal is the most important environmental problem for the dairy industry [13,14] due to its both large volume and high organic content [10,15]. Considering that whey contains about 55% of the whole milk nutrients [16], it could be a potential resource for the production of other added-value products (e.g., food supplements) [9,10]. In line with what stated by the "waste management hierarchy", this by-product has the potential to be reused as an input for other production systems [17,18].

In a circular economy prospective, a promising possibility could be the use of organic waste feedstocks (e.g., whey) for the production of innovative biopolymers such as poly(butylene-co-adipate terephthalate) (PBAT), polyhydroxyalkanoates (PHA), polylactic acid (PLA), and polyvinyl acetate (PVA) for food packaging applications [14,19-21]. These polymers are completely bio-based, biodegradable and their barrier properties are comparable to the conventional petroleum-derived alternatives [22]. Moreover, PHA is UV-resistant and oxygen-impermeable (fundamental properties for food packaging) and it is employable for the production of bottles and water-resistant film [13,14,19].

Also, biodegradable packaging could be a suitable solution in order to mitigate the removal and disposal problems of the common packages for liquid dairy products, such as HDPE (high-density polyethylene) bottles and Tetra Pak® systems [23]. Indeed, in Europe only the 10 – 15 % of the 2 million tons of HDPE bottles commonly used for UHT (ultra-high temperature) milk were recycled, according to data in 2012 [23]. Moreover, the possibility to reduce the dependence on fossil resources and their price increasing, contribute to make bio-based feedstock the favourable choice in substitution of fossil one [22,24].

Possible alternative to organic waste feedstocks (e.g., whey) is the plant-based one (e.g., corn, sugar cane etc.), which currently represents the most efficient option for the production of bioplastics [22]. However, the main barrier in using these biopolymers could be their production cost [14]. For instance, bioplastics are generally more expensive rather than conventional ones due to the higher density required [24]. According to the final report of BIOBOTTLE project, the cost of fresh milk in large biodegradable bottle increases less than 10% in comparison with the current packages [23]. However, the use of the whey could help to reduce the unit price for the production of the biopolymer by almost 23% [25].

Nowadays, food and packaging industries are joining efforts to use biodegradable materials in order to reduce the amount of plastic waste sent to landfills [10,26]. However, innovations in the food sector, including packaging, are successful only if accepted by consumers [27,28]. Thus, the introduction into the market of new packages may result in profit for food companies as long as consumers accept them and are willing to pay for such innovative solutions.

To the best of our knowledge, although many studies on sustainable consumption are available, no research investigated the Italian consumers' intention to purchase biodegradable packages for milk. Then, the goal of this research work was to analyze the consumer's intention to purchase milk biodegradable packaging through improved understanding of the factors that drive consumers toward more sustainable purchase decisions. In addition, this study qualitatively investigated the consumers' willingness to pay for milk packaged in biodegradable packaging from different raw materials such as, organic waste feedstocks (e.g., whey) as well as plant-based (e.g., corn, sugarcane etc.).

1.1. Literature review on individual driver of sustainable consumption and theoretical framework

Studies on consumers' sustainable choices are mostly focused on the Theory of Planned Behavior (TPB) [29]. This theory assumes that the intention to perform a behavior is influenced by attitudes, subjective norms and perceived behavioral control [29].

Attitudes towards a specific behavior represent the personal favorable or unfavorable evaluation of performing that behavior [30]. Reviewed studies pointed out as consumers with positive attitudes toward preserving the environment were more willing to consider sustainable packaging in their purchase decisions [31,32]. Also, studies showed that consumers with positive attitudes toward sustainable packaging also reported strong positive attitudes in favor of recycling [31,33-35]. Indeed, consumers with pro-environmental attitudes were more likely to adopt multiple sustainable behaviors, with respect to different topics such as recycling [36-39], waste management [40-43], energy consumption [45], transport use [46], the purchase of green products [47]. Thus, consumers that consider the importance of the correct packaging disposal at the end of its useful life will also be the ones willing to purchase sustainable products [31,32].

However, positive environmental attitudes are not able to predict the behavior if social norms are not considered [Rokka and Uusitalo, 2008]. The importance that society places on environmental issues plays an important role in explaining sustainable consumption behavior as well [31]. Specifically, the subjective norm is defined as the personal perception of the social pressure to behave in a certain way or not [Ajzen, 1991]. Then, consumers who perceive high social pressure to preserve the environment, by the use of sustainable packaging or disposing packages in a correct way, could be also more willing to purchase foods packaged in sustainable solutions [31,36,48-50].

Reviewed studies showed that sustainable consumption is also influenced by the perceived behavioral control [31,32,51,52]. It represents the individual perception of difficulty or simplicity to perform a specific behavior [29]. In this context, it is defined as the personal view of the capacity for contributing to solving environmental issues [31,51,52]. Then, the consumer's purchase decision could be affected by the consumer's belief that his actions or environmental practices (e.g., recycling) could help to protect the environment. Indeed, the stronger is the individual perceived behavioral control the greater is the consumer's intention to purchase food packaged in sustainable packages.

Furthermore, studies in literature confirmed the relationship on sustainable consumption is mediated by the consumer's awareness of environmental issues [31,53]. Specifically, the awareness of the risks for human health, due to environmental pollution, is considered one of the most important drivers of the consumer's intention to purchase sustainable products [54]. Furthermore, the consumer's awareness about the causes affecting environmental problems (e.g., wrong packaging disposal) is also considered significant in explaining the consumer's sustainable purchase decisions [54].

Finally, the intention to buy foods packed in sustainable packaging will traduce in reality only if the abstract intention is linked to a more concrete goal to perform a specific behavior, such as purchasing milk packed in biodegradable packaging, as also supported by the Goal Implementation Theory [55-58]. Then, Figure 1 shows the proposed empirical framework and the link between all the factors described above.

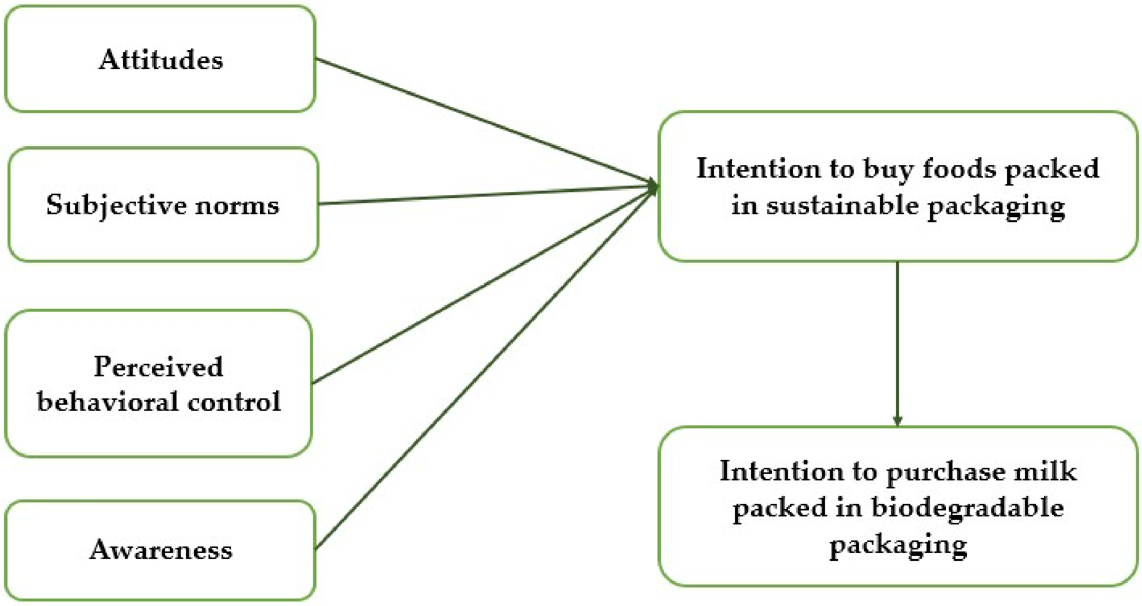

Figure1. Determinants of the consumer's intention to buy foods packed in sustainable packaging and intention to purchase milk packed in biodegradable packaging.

2. Materials and Methods

2.1. Participants and design

Data were collected by means of a web-based survey conducted in April 2020 in Italy. The survey was targeted to Italians over 18 years old, who are responsible for the food shopping in their household and who purchase milk at least once in a month. Before starting the survey, a brief explanation of biodegradable packaging was provided to respondents, as reported in Appendix A – Table A1. In this study we used a convenient sample composed by 260 respondents. Most of the respondents were female (69.6%) with an average age of 35.8 (SD = 11.7). The sample was highly educated, since 32.3% of consumers had completed high school and 66.6% had completed higher education. Most of the participants were employed (53.1%) with a family monthly income of between EUR 1,001–3,000 (46.5%). Households were composed of three members (M = 3.4; SD = 1.2) with an inconsistent number of children under 14 years old (M = 0.4; SD = 0.7). Finally, the analysis of the milk shopping habits is reported in Table 1 showing that most of the respondents usually buy Ultra High Temperature (UHT) milk (51.5%), two or more times in a week (32.2%). Most of them usually buy low-fat milk (86.9%) packaged in Tetra Pak® (55%), even if the plastic option is also very common by respondents (43.8%). Finally, most of them usually buy 1lt packs of milk (81.2%), at the unit price between €1.01 and €1.50 (37.7%), and usually buy up to ten packs in a month (67%).

Table 1. Milk shopping habits (N=260).

Categorical variables	*Sample %*
Milk shopping frequency	
Once in a day	5.8
Two or more times in a week	32.3
Once in a week	29.6
Two or more times in a month	19.2
Once in a month	13.1
Milk type	
Fresh pasteurized milk	32.7
High temperature pasteurized milk	2.3
Microfiltered milk	6.9
UHT milk	51.5
I don't know	6.5
Fat content	
Whole milk	19.6
Low-fat milk	86.9
Skim milk	13.1
Type of packaging	
Plastic	43.8
Glass	1.2
Tetra Pak®	55.0
Package's size	
0.5lt	13.1
1lt	81.2
1.5lt	5.8
Number of packages in a month	
0 - 5	33.5
6 - 10	33.5
11 - 15	18.1
16 - 20	7.3
> 20	7.6
Prize of a package	
€0 - €0.5	23.1
€0.51 - €1.00	22.3
€1.01 - €1.50	37.7
€1.51 - €2.00	13.8
> €2.00	3.1

2.2. Measures

The questionnaire contained measures of attitudes, subjective norms and perceived behavioral control toward sustainable food packaging, awareness of environmental issues and its link with human health, intention to buy foods packed in sustainable packaging, intention to purchase and to pay for milk packed in biodegradable packaging and socio-demographics. Moreover, the survey also contains questions about the milk shopping habits, as shown in the Appendix A – Table A2.

With respect to the TPB constructs, plus awareness, respondents were asked to indicate their agreement or disagreement to some statements scored on a seven-point Likert item scale ranging from "totally disagree" (1) to "totally agree" (7).

Following the TPB (Ajzen, 1991), a measure of general attitudes toward sustainable food packaging was used, assessed with 3-items scale: "Food packaging waste has negative consequences for the environment", "All food packaging should be environmentally friendly (e.g., biodegradable) to reduce their environmental impact" and "All food packaging should be environmentally friendly, even if that requires a small charge in its price". These statements were developed in accordance with the TPB and with the prior literature on sustainable consumption [31,54].

Subjective norms were composed by 2-items scale: "People who are important to me (e.g., family, friends) believe that it is very important to properly dispose of food packaging" and "The most important persons to me (relatives and friends) believe that buying food products packaged in sustainable packaging (e.g., biodegradable) is a behavior that helps to preserve the environment" [31,54].

Individual perceived behavioral control was assessed with 2-items scale: "My food packaging disposal choices have a direct impact on the environment" and "Choosing to buy food products packaged in sustainable packaging (e.g., biodegradable) contributes to solving environmental problems" [31,54].

Also, consumer's awareness of environmental issues was measured with a 2-items scale: "Environmental quality is strongly related to my health and well-being" and "Food packaging waste is one of the most important environmental issues" [54].

The intention to buy foods packaged in sustainable packaging was measured using 3-items scale: "I intend to purchase food packaged in sustainable packaging in the next future", "I plan to purchase food packaged in sustainable packaging in the next future" and "I want to purchase food packaged in sustainable packaging in the next future" [59].

Finally, to measure the intention to purchase milk packaged in biodegradable packaging, respondents were asked to indicate their intentions, with a 7-point Likert item scale ranging from "totally not willing" (1) to "totally willing" (7), related to this statement: "Are you willing to purchase milk packaged in biodegradable packaging?".

Lastly, the mean value was calculated for all the constructs measured by using multiple items scale, as shown in Appendix A – Table A3. The latter also shows the correlations between all the variables considered in the proposed empirical framework.

2.3. Estimation Method

The conceptual model proposed by the authors was tested performing the Structural Equation Modeling (SEM), through the use of STATA 14.0 software. This analysis helps to identify the magnitude and direction of the relationships between the variables. To verify the goodness-of-fit of the SEM model, the chi-square test and the incremental goodness-of-fit indices were estimated. According to Iacobucci (2010), the model works well when the Chi-Square is not significant [60]. Moreover, "the Root Mean Square Error of Approximation (RMSEA) values < 0.05 constitute good fit, values in the 0.05 to 0.08 range acceptable fit, values in the 0.08 to 0.10 range marginal fit, and values > 0.10 poor fit [61], for both the Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) values > 0.95 constitute good fit and values > 0.90 acceptable fit [62,63] and Standardized Root Mean Square Residual (SRMR) should be lower than .08 [64].

3. Results

Results obtained by testing the empirical framework are shown in Table 2. The model showed an acceptable goodness of fit considering that the RMSEA was between 0.05 and 0.08 range; both the CFI and TLI values were higher than 0.95 and the SRMR value was extremely lower than 0.08. Overall, explained variance was equal to 46.07%.

Table 2. The structural model of the consumer's intention to buy foods packed in sustainable packaging and then to purchase milk packed in biodegradable packaging.

Parameters	**Intention to purchase milk packed in biodegradable packaging**
	Coefficient
Intention to buy foods packed in sustainable packaging	0.555***
	Intention to buy foods packed in sustainable packaging
Attitudes	0.468***
Subjective norms	0.100**
Perceived Behavioral Control	0.287***
Awareness	0.138*
Age	-0.002
Gender	-0.100
Education's level	0.167
Indexes of goodness-of-fit	
R^2	46.07%
Likelihood Ratio χ 2 (6)	14.01 p-value <0.05
RMSEA	0.072
CFI	0.969
TLI	0.922
SRMR	0.020

Note: *, ** and *** indicate 10, 5, and 1 percent significance levels, respectively.

Results from the model showed that the individual intention to buy foods packaged in sustainable packaging was a good predictor of the consumer's intention to purchase milk packed in biodegradable packaging (0.555 $p < 0.001$). With respect to the determinants of the intention to assume a more ecological purchase behavior, all the variables concerning the TPB were significantly and positively related to the individual's intention to buy foods packaged in sustainable packaging. In detail, attitude towards sustainable packaging was the most important driver of the personal intention to perform the behavior (0.468 $p < 0.001$), followed by perceived behavioral control (0.287 p < 0.001) and subjective norms (0.100 p < 0.05). This finding was also consistent with the correlation matrix shown in Appendix A – Table A3, third column, reporting the correlation index between the attitudes and the intention to buy foods packaged in sustainable packaging as the highest. The consumer's awareness of environmental issues was also an important predictor of the individual intention, with magnitude of the coefficients equal to 0.138 (p < .01). However, the socio-demographics characteristics such as, age, gender and the education's level, inserted as control variables, did not affect the consumer's intention to buy foods packaged in sustainable packaging.

3.1. Willingness to purchase and to pay for milk packed in biodegradable packaging

Results showed that almost the totality of the respondents (92%) who intended to buy foods packaged in sustainable packaging were also willing to purchase milk packed in biodegradable packaging in order to improve the environmental wellbeing (58,6%), as shown in Appendix A – Table A4. However, consumers mostly preferred the use of plant-based raw materials (e.g., corn, sugarcane etc.) (55.65%) rather than the use of organic waste feedstocks (e.g., whey) (44.35%). Indeed, most of the respondents disliked the idea to use wastes to create food packaging (N=47) as well as using organic waste feedstocks (e.g., whey) was perceived as potentially risky for human health (N=41). Finally, most of the consumers were also willing to pay 1% - 5% more for milk packed in biodegradable packaging made from organic waste feedstocks (43.40%) as well as from plants (51.88%), as shown in Table 3. A large portion of respondents, equal to 28.87% and 30.83%, would also be willing to pay 6% - 10% more for organic waste and plant-based packaging for milk, respectively. Only 7.95% of consumers were not willing to pay a premium price for milk packaged in biodegradable packaging.

Table 3. Consumer's willingness to pay a premium price for milk packaged in biodegradable packaging.

Willingness to pay a premium price	*Plant-based feedstocks*		*Organic waste feedstocks*		*TOTAL*	
	N	%	N	%	N	%
0% more	11	8.27	8	7.55	19	7.95
1% - 5% more	69	51.88	46	43.40	115	48.12
6% - 10% more	41	30.83	28	26.42	69	28.87
11% - 15% more	8	6.02	15	14.15	23	9.62
16% - 20% more	4	3.01	9	8.49	13	5.44
TOTAL	*133*	*100*	*106*	*100*	*239*	*100*

4. Discussion

The present study investigated which factors are able to drive consumers toward more ecological purchase decisions through an extended TPB model which turned out to be relevant in explaining the consumer's intention to buy foods packaged in sustainable packaging.

Results highlighted that attitude was the most important predictor of the personal intention to behave in a pro-environmental way. This finding was supported by Van Birgelen et al. (2009) who, in their study on German consumers (n= 176), pointed out that respondents who showed positive attitudes toward preserving the environment were more willing to consider sustainable packaging in their beverage purchase decisions [31]. This result was consistent with the study of Mobrezi and Khoshtinat (2016), on Iranian consumers (n=279), showing that the intention to buy undefined sustainable products increased by the rising of positive attitudes toward the environment [65]. Attitude about using sustainable products had a positive and a significant association with the behavioral intention for other studies present in literature [66-68].

In our research, perceived behavioral control was the second most important driver of the consumers' intention to purchase foods packaged in sustainable packaging. Then, respondents who recognized the importance to assume more ecological purchase behavior, to preserve the environment, were also more likely to buy sustainable packaging for foods and thus for milk. This is consistent with the research of Auliandri et al. (2019), on Indonesian consumers (n=276), showing positive influence of perceived behavioral control on the purchase intention toward undefined sustainable packaging [69]. Similar results were also found by many other studies present in literature [31,54,66].

Additionally, subjective norms emerged to be positively and significantly related to the intention to assume sustainable purchase decisions. This could mean that what others believe is important is able to influence the individual behavior. This result was supported by Van Birgelen et al. (2009) and Auliandri et al. (2019) highlighting how the social perception about sustainable products and their importance to improve the environmental wellbeing encourage consumers to buy foods packaged in sustainable packaging [31,69]. Contrasting findings were found by Chen and Hung (2016), in their study on Chinese consumers (n=406), and Mobrezi and Khoshtinat (2016) showing as the role of social pressure, exercised by relatives and close friends, is not significantly related to the intention in purchasing undefined sustainable products [65,66].

Furthermore, results from our research showed that people with high environmental consciousness as well as being aware about the risks for the human health, due to the environmental pollution, were also more likely to consider sustainable packaging in their purchase decisions. This finding is consistent with many studies present in literature suggesting that the consumer's intention to buy sustainable products usually increases by the rising of environmental concerns [31,54,65].

Finally, socio-demographics characteristics such as, age, gender and the education's level, inserted as control variables, were found to be not significant in explaining the consumer's intention to buy foods packaged in sustainable packaging. This result was supported by Suki (2013), in a study on Malaysian consumers (n=200), who confirmed that respondents' demographics (e.g., gender, age) did not affect the consumer's pro-environmental behavior [70]. Contrasting findings were found by Rokka and Uusitalo (2008) who, in their study on Finland respondents (n=330), showed that sustainable packaging buyers are usually more likely to be female and older consumers. The education's level instead was not found to be significant in affecting the consumers' intention to buy sustainable packaging [48]. This could be due to the greater attention that the media has given on environmental issues thus managing to involve consumers with lower education's level.

Once identified the drivers of the personal intention to assume more ecological purchase decisions, this research aimed at analyzing the consumer's intention to buy milk packaged in biodegradable packaging as well as to investigate how the respondent's willingness to pay varies from different raw materials such as, organic waste feedstocks (e.g., whey) as well as plant-based (e.g., corn, sugarcane etc.).

Results showed that almost the totality of the interviewed were willing to purchase milk in biodegradable packaging to improve the environmental wellbeing. This finding was supported by Koutsimanis et al. (2012) who, in their study on North Americans (n=292), showed that bio-based packaging for fresh foods was the most preferred option by consumers [71], rather than the conventional ones, as well as Arboretti and Bordignon (2016), in their study on Italian and Austrian respondents (n=205), found that the biodegradability was the favored food packaging attribute for the consumer final choice [72]. Moreover, many studies present in literature suggested that perceived benefits were the significant predictors of the consumer's intention to purchase sustainable packaging. Then, the protection of the environment as well as the reduction of the risks for human health were the main reasons for individual pro-environmental behavior [73,75].

Further results of our study highlighted that the plant-based feedstock (e.g., corn, sugarcane etc.) was the favored raw material for milk biodegradable packaging, although a great share of respondents chose the organic waste option (e.g., whey). In this regard, perceived risk for human health was one of the principal reasons for rejection of biodegradable packaging made from organic waste feedstock. Similar results were found by Magnier et al. (2019) who, in their study on Dutch consumers (n=258), found that the risks of contamination negatively influenced the consumer's purchase intention of products made from recycled ocean plastics [76]

Finally, most of the respondents in our research were also willing to pay a premium price for milk packaged in biodegradable packaging regardless of the origin of the raw material used. This finding was consistent with Grebitus et al. (2020) who, in their study on North Americans (n=109), found that consumers who received pro-environmental guidance appeared to be willing to pay a higher price for both plant-based and recycled plastics [77]. Similar results were observed by previous studies present in literature showing that most of the consumers are usually willing to pay a premium price for sustainable packaging, including 81% of the participants in a study conducted in the USA [78], as well as 67% and 86% of the respondents of surveys conducted in Germany and Sweden, respectively [31,79].

5. Conclusions

The present work provides relevant information about the factors able to drive consumers toward more sustainable purchase decisions. Results show that pro-environmental attitudes, perceived control over the individual actions (e.g., recycling), the social pressure to preserve the environment as well as the consumer's awareness for the environmental issues are able to explain the personal intention to purchase sustainable packaging for foods, and thus for milk. Furthermore, findings highlight that consumers slightly prefer plant-based (e.g., corn, sugarcane etc.) biodegradable packaging for milk. Indeed, the use of organic waste feedstocks (e.g., whey) for food packaging applications is perceived as potentially risky for human health by some respondents. However, regardless of the renewable origin of the raw material, consumers are willing to pay 1% - 5% more for milk within sustainable packaging.

Given the absence of studies on this topic and specifically on the consumer's intention to purchase a defined food product (e.g., milk) packaged in sustainable alternatives, these results may fill the gap in literature for the Italian market contributing to improve the knowledge in this field. Then, these findings come with important policy and marketing implications. Policymakers and companies may develop informational and educational campaigns to raise the level of awareness about the negative impact of packaging waste on the environment as well as on human health, which may have an important role in supporting behavioral changes toward more sustainable purchasing options. Additionally, companies may also promote with marketing campaigns the use of organic waste feedstocks to create biodegradable packaging. Such a message should focus on increasing the consumer's knowledge about the use of whey as totally safe food contact material, considering also that this by-product of the dairy industry is commonly used to produce food supplements (e.g., whey proteins). In this regard, policymakers should encourage, with incentive based-policy (e.g., tax relief), companies to reuse the whey for the production of value-added products to increase the efficiency of the dairy industry and adopt closed-loop recycled systems.

Finally, some limitations should be considered to evaluate our results. First, given the sample size, these findings cannot be generalized to the Italian population as well as to other geographical contexts. Moreover, the sample is mostly composed of respondents with a high education's level which could significantly affect our results, specifically with reference to the consumer's attitudes, their perceived behavioral control, subjective norms as well as their awareness. Second, the total variance explained by our model, equal to around 46%, could mean that the TPB alone is not able to explain all the possible factors able to drive consumers toward more sustainable purchasing behaviors. Moreover, results show that consumers willing to purchase foods packaged in sustainable packaging will have a 50% chance to also choose milk in biodegradable containers. This could highlight a difficulty for consumers to change their purchasing habits also in relationship with the packaging. Indeed, most respondents usually buy milk in Tetra Pak® that could be considered by consumers as an already sustainable option than plastic as well as able to ensure food safety and shelf-life.

Thus, future research will be focused to overcome the limitations listed above using a larger and more representative sample of the Italian population. Moreover, the use of a different methodology (e.g., stated choice experiments) could help to fill the gap of the TPB in order to better identify the possible drivers of the consumer's intention to purchase milk packaged in biodegradable packaging and then to pay a premium price for it.

Appendix A

Table A1. General information about biodegradable packaging

Technology	Description
Biodegradable packaging	"Biodegradable materials are materials that can be broken down by microorganisms (bacteria or fungi) into water, naturally occurring gases like carbon dioxide (CO2) and methane (CH4) and biomass (e.g., growth of the microorganism population). Biodegradability depends strongly on the environmental conditions: temperature, presence of microorganisms, presence of oxygen and water. So, both the biodegradability and the degradation rate of a biodegradable packaging may be different in the soil, on the soil, in humid or dry climate, in surface water, in marine water, or in human made systems like home composting, industrial composting or anaerobic digestion [Van den Oever et al., 2017]". Finally, biodegradable packaging can be bio-based which means that the material or product is totally or partly derived from biomass. Today, bio-based and biodegradable packaging are mostly made of carbohydrate-rich plants such as corn or sugarcane, so called food crops or first-generation feedstock. However, this kind of packaging can also be made from ligno-cellulosic feedstock such as plants that are not eligible for food and feed production or from organic waste feedstocks (e.g., whey) [European Bioplastics, 2018; ENEA, 2018].

Table A2. The questionnaire's structure.

Section	Questions	Response Variable	Response Option
1. *Milk Shopping Habits*	Milk shopping frequency	Multiple Choice	Once in a day; two or more times in a week; once in a week; two or more times in a month; once in a month.
	Type of milk	Multiple Choice	Fresh pasteurized milk; high temperature pasteurized milk; microfiltered milk; UHT (Ultra High Temperature) milk; I don't know.
	Fat content	Multiple Choice	Whole milk; low-fat milk; skim milk.
	Type of packaging	Multiple Choice	Plastic; Glass; Tetra Pak.

	Package’s size	Multiple Choice	0,5lt; 1lt;1,5tl; other.
	Number of packages in a month	Open-ended	numeric
	Prize of a package	Open-ended	numeric
2. Theory of Planned Behavior	Awareness, Attitudes, Subjective norms, Perceived Behavioral control, Intention to buy foods packed by sustainable packaging	Likert scale	7-point Likert scale ranging from 1 (totally disagree) to 7 (totally agree)
3. Intention to purchase and to pay for milk packed by biodegradable packaging	Intention to purchase	Likert scale	7-point Likert scale ranging from 1 (totally not willing) to 7 (totally willing)
	Renewable origin of milk packaging	Dichotomous	plant-based feedstocks (e.g., corn, sugarcane etc.); organic waste feedstocks (e.g., whey).
	Reason of the intention to purchase	Multiple Choice	Improvement of the environmental wellbeing; reduction of the dependence on fossil resources; disposing of the package with organic waste; creation of biogas and compost from the industrial composting; other.
	Reason of rejection	Multiple Choice	Price increasing; mechanical characteristics inferior to traditional packaging; risks for human health; others.
	Willingness to pay a premium price	Multiple Choice	0% more; 1% - 5% more; 6% - 10% more; 11% - 15% more; 16% - 20% more.
4.Socio-demographics	Age	Open-ended	numeric

Gender	Multiple Choice	Male; female
Education's level	Multiple Choice	Primary School; Middle school; High School; Bachelor's degree; Master's degree; Postgraduate (e.g., PhD, master)
Occupation	Multiple Choice	Not employed/student/house wife; Retired; Blue-collars; White-collars; Managers; Self-employed
Family monthly income	Multiple Choice	Up to EUR 1,000; EUR 1,001–3,000; EUR 3,001-5,000; EUR 5,001-7,000; EUR 7,001 and over
Household size, Number of children (under 14 years old), Number of employed in family (excluding interviewed)	Open-ended	numeric

Table A3. Descriptive statistics and correlations (N=260).

Variables	***Mean***	***S.D.***	**1.**	**2.**	**3.**	**4.**	**5.**	**6.**
1. Intention to buy foods packed by sustainable packaging	6.32	0.89	1					
2. Attitudes	6.44	0.65	0.58*	1				
3. Subjective norms	6.96	1.06	0.40*	0.39*	1			
4. Perceived behavioral control	6.34	0.82	0.57*	0.54*	0.43*	1		
5. Awareness	6.56	0.62	0.43*	0.52*	0.28*	0.55*	1	
6. Intention to purchase milk packed by biodegradable packaging	5.63	0.67	0.56*	0.45*	0.24*	0.37*	0.41*	1

Note: * indicate 1 percent significant levels, respectively.

Table A4. Reasons for the intention to purchase biodegradable packaging for milk (N=239).

Reasons	**N**	**%**
1. Improvement of the environmental wellbeing	140	58.6
2. Possibility to reduce the dependence on fossil resources	47	19.7
3. Possibility to create biogas and compost from the industrial composting process	34	14.2
4. Reduction of time to devote to separate collection (disposal with organic waste)	15	6.3
5. No one of these reasons	3	1.2

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Chapter 5

PACKAGING INNOVATIONS TO REDUCE FOOD LOSS AND WASTE: ARE ITALIAN MANUFACTURERS WILLING TO INVEST?

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Abstract: The target 12.3 of the 2030 Agenda by the United Nations (UN) calls for halving per capita global food loss and waste. In this regard, the Food & Drink industry (F&D) could play a crucial role in reducing food waste and improving food safety by adopting healthy and eco-innovation packaging. Thus, this paper aims to investigate the F&D manufacturers' willingness to invest in packaging innovations, such as active, intelligent, and compostable ones to achieve the UN target. In order to reach the stated objective, a multiple case study methodology was developed and administered to a sample of Italian micro and small-medium entrepreneurs located in the Apulia region. Results show that many firms were aware of their need for packaging innovation and of the available technological opportunity. However, only the F&D manufacturers who showed a Real demand, according to a taxonomy approach which also considers the Potential and Latent demand for the innovation, were effectively prompt to invest. Finally, most of the interviewed manufacturers were willing to invest in at least one packaging innovation, choosing mainly between the active packaging and the compostable one.

Keywords: food waste; food safety; demand for innovation; packaging innovations; eco-innovation; health innovation; Food & Drink industry; micro and SMEs; manufactures' willingness to invest

1. Introduction

Currently, the agro-food system feeds the worldwide population of 7.7 billion people, and it will have to provide additional food for another 2 billion by 2050 [1]. This means an increasing demand of 60% by 2050, resulting in increasing pressure on the scarce resources required for food production such as water, land and energy [2,3]. Moreover, in a world where some 850 million people live with chronic hunger [3], reducing the amount of Food Loss and Waste (FLW) is widely seen as a way to increase the efficacy of the agro-food system and improve food security [4,5]. FLW is the decrease in quantity or quality of food resulting from decisions and actions of all the actors of the Food Supply Chain (FSC) [4]. Specifically, Food Loss (FL) occurs at the production, post-harvest, and processing stages in the FSC. Food Waste (FW) takes place at the retail and consumption level [6]. Every year, about a third of the food produced for human consumption is lost or wasted, with the associated cost estimated to be equal to USD750 billion [5,7]. Furthermore, the environmental impact is far more significant, considering that FLW alone generates about 8% of the total Greenhouse Gas (GHG) emissions [8].

The growing attention on this issue is reflected in the 2030 Agenda, adopted by the United Nations (UN) Member states in 2015, which provides 17 different Sustainable Development Goals (SDGs). Among them, the SDG 12, related to responsible production and consumption, includes the target 12.3 that calls for halving per capita global FLW by 2030 [4,5]. Furthermore, as recognized also by the European Commission (EC), all actions connected to food have a direct or an indirect link with the SDGs, because it affects the health of people, societies, and the planet [9,10]. Thus, hitting the target of halving FLW means also to help the achievement of the SDG 1 (ending poverty), of the SDG 2 (zero hunger), related to food security and improved nutrition, and other targets regarding environmental sustainability (e.g., SDG 6, SDG 13) [4,9,11].

In this context, the Food & Drink (F&D) industry can play a role in reducing FLW through its prevention, reuse and recycle, and promoting more sustainable production and consumption patterns [5,12]. In industrialized countries, where more than 40% of the whole FLW occurs at the final stages of the FSC [7], the adoption of different key processes, such as the implementations of the requirement of the ISO 22000 Standard, concerning the development of food safety management system, could contribute in tackling this issue [13]. Among these drivers, the adoption of primary packaging innovations assumes particular importance for manufacturers since it can help to prevent the generation of FW [14–16].

It is well known that the role of packaging in the FSC is relative to the maintenance of food quality, integrity and safety; it also supports the food delivery, facilitating transport and storage, with direct economic benefits, and contributes to enhancing its shelf-life [15,17–19]. A deficient packaging material is considered, on the contrary, one of the main causes of the generation of FLW [20]. Thus, it is very crucial to adopt innovations in food packaging to tackle this issue, minimizing the FLW amount. It is possible to distinguish two typologies of innovation in packaging: health and ecological ones. The paper focuses mainly on the active and intelligent packaging, for the health innovation, and on the compostable packaging for the eco-innovation.

The active and intelligent packaging allows to maintain food quality and to extend food shelf-life and to monitor the freshness of foods [21–23], respectively, as established by the Regulation 1933/2004/EC and 450/2009/EC [21,24]. The active packaging is in particular designed to deliberately incorporate components that may release substances into the packaged food or the surrounding environment or absorb some substances from food or the environment [15,16,25–30]. The key function of intelligent packaging, instead, is to record the environmental conditions both inside and outside the packaging through the use of internal (inside the package) or external (outside the package) sensors or indicators [27,31]. The recent European Directive on waste (2018/851), that introduces the waste hierarchy, points out the importance of preventing FLW as the first strategy to be adopted by all the actors of the FSC. Thus, these health innovations are considered a way to avoid FLW [32].

The compostable packaging, on the other hand, could be considered an alternative option whenever the prevention of FLW is not feasible, as stressed by the waste hierarchy [12,32,33]. This latter promotes the FLW reuse as raw materials for the production of biopolymers for eco-innovations in packaging [34,35]. Indeed, in a Circular Economy (CE) perspective, FL from production processes and FW from consumers can be reused as a direct or indirect source of inputs for other processes, minimizing resource scarcity and overexploitation [36–38]. Then, compostable packaging could be completely biodegradable, bio-based, and its chemical, physical, and mechanical properties are comparable to petroleum-derived plastics [34,35,39–43]. Compostability is the ability of a material to turn into compost within 3 months through the industrial composting process, according to the EN 13432 standard [39]. During the past years, the F&D industry has shown great interest in these innovations, since they can represent a suitable solution to enhance resource efficiency and to lower emissions that would have been generated in extracting and processing non-renewable raw materials [39–41].

Both health and eco-innovation in the F&D packaging are already on the market, presenting very interesting characteristics, although they are not so common among manufacturers. Indeed, looking at the Summary Innovation index during the period of 2010–2017, and at the EU-28 level, even if the innovation performance has improved in the F&D industry, often the intellectual property rights do not cover the results of the innovative activities in some countries [44]. Thus, this evidence could represent a barrier to investment in innovations above all for micro, small and medium-sized enterprises (SMEs), which often cannot rely on internal sources of knowledge [45–47]. This means that companies must be "open" to collaborate with universities, research institutes, agencies, as well as suppliers and related industries (including chemicals and packaging sectors) [46,48].

A further important aspect that affects both consumers and producers is the absence of dangerousness of materials in contact with food. Plastics, coatings, paper and board appear to be a significant source of hazardous substances; even printing inks and adhesives are characterized by dangerous elements [49]. In this contest a large introduction of eco and health packaging in the food sector represents a powerful tool to ensure more sustainable production and healthier consumption.

In the light of these premises, the present paper aims at analysing whether the Italian micro and SMEs are willing to invest in F&D packaging innovations, such as active, intelligent and compostable packaging, in order to contribute to reducing FLW. Specifically, the study focuses on 20 micro and SMEs, located in Apulia that represents the Italian region with the highest number of the agro-food companies [50,51]. The methodology used is the multiple case study able to highlight similarities and differences among the micro and SMEs' preferences related to packaging innovations. Finally, the theoretical model proposed by Muscio et al., (2010) [52] is used to verify if the eventual manufacturers' willingness to invest could be considered as real.

To the best of our knowledge, there are many studies on the correlation between the reduction of FLW and the use of health and eco-innovations in packaging. Nevertheless, most of them are mainly focused on the technological aspect of packages, on the evaluation of the consumer's acceptance, as well as on their environmental sustainability assessment (see Section 2). Thus, there is a gap in the literature review due to the lack of a complete economic analysis related to determining the manufacturers' willingness to invest for both health and eco-innovation innovations. Furthermore, there are no studies conducted on this topic with focus in the Italian market, specifically, on the Apulia region. Consequently, this paper could be considered the first attempt to identify the main drivers and barriers in the micro and SMEs' willingness to implement F&D packaging innovations into the market for reducing FLW. This element, as well as the theoretical framework developed, represents the novelty and originality of this research that could contribute to providing useful insights for addressing the agro-food system towards a more sustainable pathway, in compliance with the pandemic crisis we are living in.

This research, identifying the most promising innovations in food packaging, could contribute to make companies more aware of the technology supplier in the field of health and eco innovation and to be competitive in the global market by differentiating the product through innovative packaging. Moreover, a better understanding of the adoption of eco and health innovations can be of great interest not only to the research but also to the policymakers who are deputies to promote environmental sustainability and human health.

2. Literature Review

Based on the main literature review, it has been possible to highlight what scholars on this topic have done. There are many studies on the correlation between the reduction of FLW and the use of active, intelligent and sustainable packaging. Nevertheless, most of them are principally focused on the technological aspect of packages, on the evaluation of the consumer's acceptance, as well as on their environmental sustainability assessment. Consequently, a few are addressed to evaluate the manufacturer's willingness to invest towards these technological solutions aimed to reduce FLW. In this section, the authors reported some main references as examples of the different studies' approaches.

About the technological approach, Poyatos-Racionero et al., (2018) conducted an analysis of intelligent packaging, specifically different optical systems, for monitoring freshness of fruits, vegetables, fish products and meat, since they are more prone to be wasted. They stressed that these dynamic systems are able to inform about the real state of food, reducing FW, while maintaining food safety. Furthermore, they observed that technological advances in this field could promote a greater adoption of intelligent packaging by F&D industries [53]. Moreover, Bhargava et al., (2020) highlighted the possibility to use FW for producing bioactive compounds in active and intelligent biodegradable packaging films. These are economical, safe, non-toxic, sensitive, easy to be manufactured and commercialized for fresh food products in order to evaluate the visual quality in a simple way [54]. In this context, Firouz et al., (2021) underlined that these emerging technologies present some important barriers to be considered, such as the production costs, the complexity of these technologies as well as the consumers' acceptance. Thus, it is very important to analyze in depth these concerns to extend the applications in the food industry [55]. Jõgi and Bhat (2020), instead, focused on an overview of bioplastics, including production methods and possibilities of industrial food waste valorization for bioplastic production for the F&D packaging applications. They observed that the most important limit, concerning the production and usage of these products, is their cost-effectiveness. Then to reduce this issue, cheap and abundant raw materials, such as food wastes and by-products can efficiently be explored [56].

About the consumers' acceptance approach, Aday and Yener (2015) and Challaghan and Kerry (2016) showed that consumers prefer intelligent packages more than active ones because they want to monitor food quality and the remaining time for eating it [57,58]. Wilson et al., (2018) highlighted that consumers mostly prefer active packaging without the use of sachets/labels due to the fear of being swallowed [59]. Furthermore, a general lack of consumers' knowledge as regards such innovations is stressed by Aday and Yener (2013) and Barska and Wyrwa (2016) [57,60]. Thus, they pointed out the need to increase the consumers' acceptance of these technologies by media communications strategies and information campaigns. Koenig-Lewis et al., (2014), alternatively, focused their attention on the evaluation of consumers' emotional and rational evaluation of sustainable packaging. Results showed that the consumer's willingness to purchase was more significantly influenced by general environmental concern rather than the rational evaluation of the benefits. Then, the authors suggested that marketers should emphasize the positive emotions evoked by using ecological packaging to advertise [61]. Brennan et al., (2020) presented a systematized literature review of consumer food waste in households, packaging technologies to reduce food waste, and consumer perceptions of packaging. Specifically, they stressed that there is little research on the role of consumers' perceptions in reducing food waste by using packaging innovations. This could turn into a reduced consumers' willingness to purchase and to pay a premium price for these technologies [62].

Regarding the environmental sustainability assessment of these packaging innovations, Dilkes-Hoffman et al., (2018) carried out a study on the quantification of the GHG trade-offs associated with the use of a biodegradable packaging. They revealed that to effectively cut these emissions it's important to consider also the food packaging design (e.g., high barrier properties) and not only the bio-based raw material. Thus, the key design aspect should be the reduction of food waste [63]. In the same direction, Kakadellis and Harris (2020) highlighted that, although it is difficult currently to identify what biopolymer for biodegradable plastics is the best solution for reducing food waste, it is critical to focus on food packaging performance in food waste minimization. This means to emphasize the environmental footprint associated with food production and food waste, and to highlight the importance of including the food itself in food packaging LCAs [64]. Additionally, an interesting study provided by Zhang et al., (2021) showed that the carbon footprint of the nano-packaging system could be reduced thanks to the decrease of FW deriving from the extension of the shell life of the food product. The results are expected to provide food manufacturers with the groundwork to make more informed decisions on nano-packaging applications [65].

Finally, concerning the manufacturers' willingness to invest, Simms et al., (2020) stressed that the literature on eco-innovation adoption has often overlooked the food processing sector. Thus, they examined the barriers inhibiting the adoption of waste reducing eco-innovations in the food processing sector. They found different barriers to the adoption of waste reducing technologies in the food processing sector, such as the influence of technologies on the product's characteristics, its retailing, and a perceived lack of consumer demand. The study suggests useful information for policy makers and innovation managers to increase the adoption and diffusion of these technologies in the food processing sector [66]. Fonseca et al., (2018) conducted an online survey among 99 Portuguese companies to evaluate their willingness to move from a linear to a CE. Then, results showed that CE activities are still relatively modest and additional government actions are required to promote it, as well as a stronger support from all the actors of the FSC [36]. Finally, Keränen et al., (2020) studied the changes to existing industry value networks that can facilitate the diffusion of sustainable innovation in food packaging. They considered the transformation and distribution of agro-food waste into a new bioplastic packaging. Their results stressed the importance of opportunity recognition, but also the role of new actors, resources, activities, and relationships in restructuring this network [67].

Thus, there is a gap in the literature review due to the lack of a complete economic analysis related to determining the manufacturers' willingness to invest for both health and eco-innovation innovations. Furthermore, there are no studies conducted on this topic with focus in the Italian market, specifically, on the Apulia region.

3. Materials and Methods

3.1 Theoretical Model

In order to reach the research goal, the theoretical model proposed by Muscio et al., (2010), "Firm's demand for innovation", was used to verify if the eventual manufacturers' willingness to invest for packaging innovations could be considered as real [52]. Indeed, according to this taxonomy, the demand for innovation could be determined by the combination of the awareness of their needs and the knowledge about the technological solution to address their needs. Then, three typologies of demand for innovation were identified:

- Real demand: firms are aware of their needs and know how to act in order to improve their products/processes;
- Latent demand: firms have a limited capacity to translate their needs into potential innovation processes;
- Potential demand: firms' innovation needs are not explicated because there are no firms in the area capable of responding to certain innovation challenges.

In this study, while the theoretical model proposed by Muscio et al., (2010) [52] focused on analysing the business needs in terms of improvements to a firm's products and processes, the theoretical framework we propose focuses on the firm's demand for packaging innovations. Then, as aforementioned in the introduction section, the technologies proposed are: active, intelligent and compostable packaging. Table 1 shows the principal innovation needs and the relative existing packaging technologies to address them.

Table 1. Firm's innovation needs and relative proposed packaging innovations.

Business Innovation Need	Existing Technology
Extend the shelf-life of packaged foods or drinks	Active packaging
Provide information about food's freshness and safety	Intelligent packaging
Reduce the environmental impact of the packaging	Compostable packaging

Table 2 shows the adaptation of the theoretical model proposed by Muscio et al., (2010) [52] to our case study. Specifically, the real demand was integrated by the authors with an additional characteristic in which the firm' capacity to translate need into packaging innovation could be not only autonomous but also dependent on external sources of knowledge.

Table 2. Firm's demand for innovation.

Type of demand	Description	Firm's awareness about own packaging need	Firm's awareness about the required packaging technology	Firm's capacity to translate the need into a packaging innovation

Real	Firm has a specific need and it is aware of the technological packaging solution to address its need	Aware	Aware	Autonomous/ Dependent
Latent	Firm has a specific need but it is not aware of the technological packaging solution to address its need	Aware	Not aware	Dependent
Potential	The firm doesn't express a specific need	Not aware	Not aware/Aware	Unconscious

Through the use of this theoretical model, we will be able to analyze if the willingness to invest for packaging innovations (active, intelligent and compostable packaging), expressed by F&D manufacturers, could be considered as a real, latent or a potential demand. Figure 1 shows the logical flow of the theoretical model proposed by the authors. It will be tested through a multiple case study methodology, which involves 20 micro and SMEs located in Apulia region (Italy).

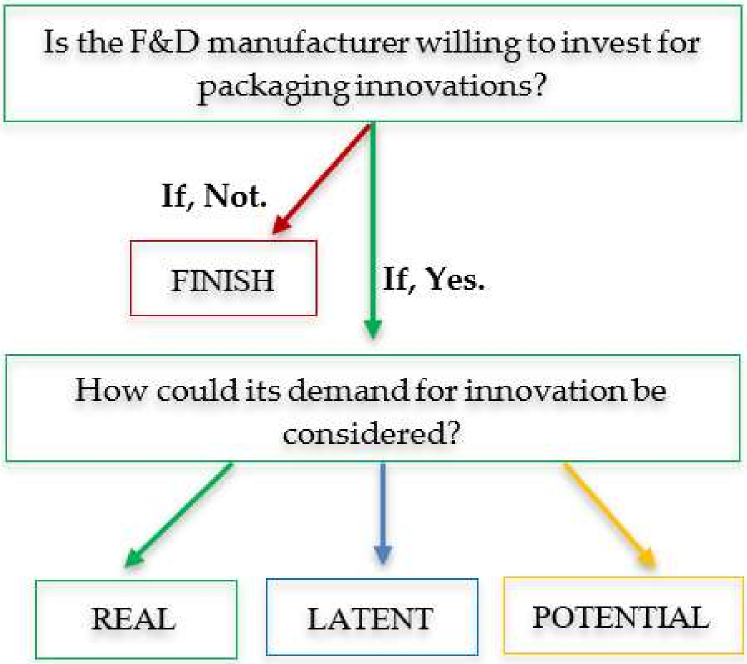

Figure 1. Demand for packaging innovation theoretical model.

3.2 Methodology: multiple case study

Qualitative research methodologies, such as case studies, are recognized to be particularly suitable during preliminary stages of the investigation of a phenomenon [68–70]. The case study is a research strategy focused on understanding the dynamics present within single settings. This methodology can involve either single or multiple cases, and different levels of analysis [69,70]. In this context, we used a multiple case study methodology because it allows both an in-depth examination of each case and the identification of similarities and differences between all cases [71,72]. Moreover, the outcomes are commonly better grounded than results from single case studies [72]. Thus, our study is focused on 20 micro and SMEs located in Apulia region (Italy) involved in the production of five different mainstream products. These have been named and referred to with an alphabetical letter: fruit and vegetables (F), meat and fish (M), bakery foods (B), dairy products (D), wine (W) (Figure 2). Specifically, four F&D manufacturers were selected for each economic sector. Thus, in the description of the sample and the empirical analysis, each company has been numbered from 1 to 4.

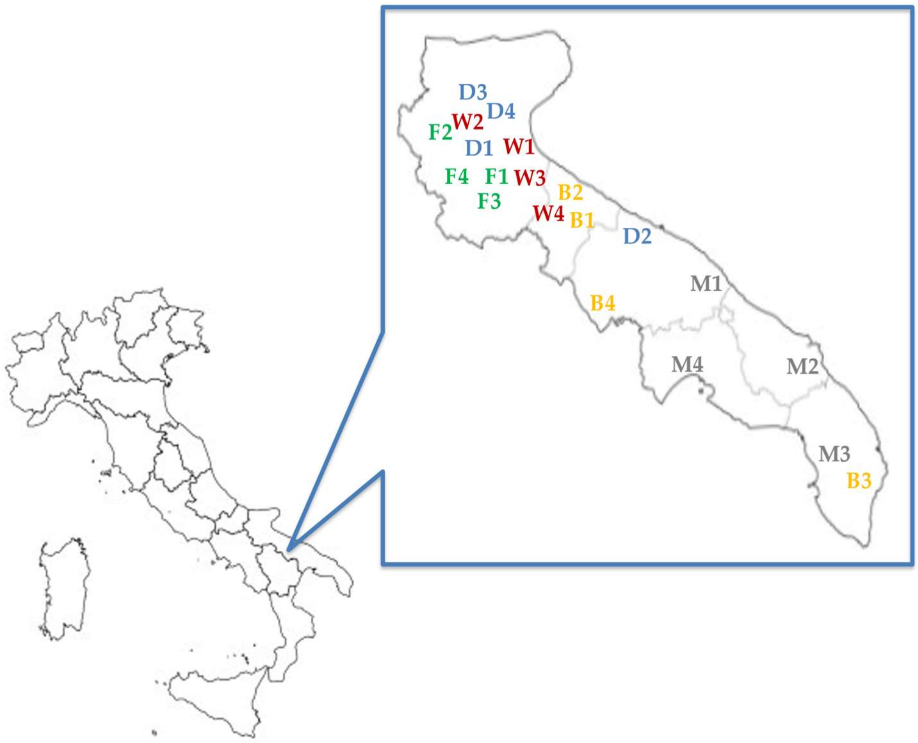

Figure 2. Location of the 20 micro and SMEs Apulian F&D manufacturers.

3.3 Data collection

Our theoretical model was tested through the use of a survey on 20 micro and SMEs located in Apulia region (Italy). The sample was identified through a stratified probabilistic procedure with reference to the economic sector and the province in which the companies belong. Participants were selected through the icribs.com website that contain a list of all the Italian companies divided according to the National Institute of Statistics' classification of the economic activities (ATECO) [73]; 92 companies were contacted by phone and a questionnaire was sent after their approval, with a response rate of 22%. The questionnaire was elaborated by the authors using Google Module and sent by email. We used a semi structured questionnaire with open and close-ended questions, based on the theoretical model illustrated in the previous section. Specifically, the survey was composed of nine sections, as shown in the Appendix A—Table A1 and carried out from November 2019 to April 2020. Then, the chosen methodology allowed the collection of a wide array of qualitative information starting from the general characteristics of the company (e.g., identification data, business details, human resources) to information on innovation activity in the F&D industry related to the packaging, as well as the definition of different demands for innovation.

4. Results

The descriptive analysis revealed that most of these companies are small (40%), followed by medium (35%) and micro-sized companies (25%). Specifically, 60% are family businesses and 30% are farms. The distribution of sales is mainly oriented on the national (41%) and regional market (33%). Moreover, the average percentage of graduates, with respect to the total number of employees, seems to be very low (22%). Finally, companies show a limited Research and Development (R&D) effort: 30% of companies' investments in R&D during the last three years accounted for 0% of sales (see for more details Appendix A—Table A2). Although 85% of these companies started product innovation strategies over the past three years, R&D was found as one of the most widespread points of weakness (25%). Moreover, access to financial resources was found as one of the most constraining factors in developing innovations (65%), as shown in Figure 3. About 70% of the F&D manufacturers considered the collaboration with suppliers in generating innovations important, while 65% declared to be willing to cooperate with universities and research institutes to develop innovations.

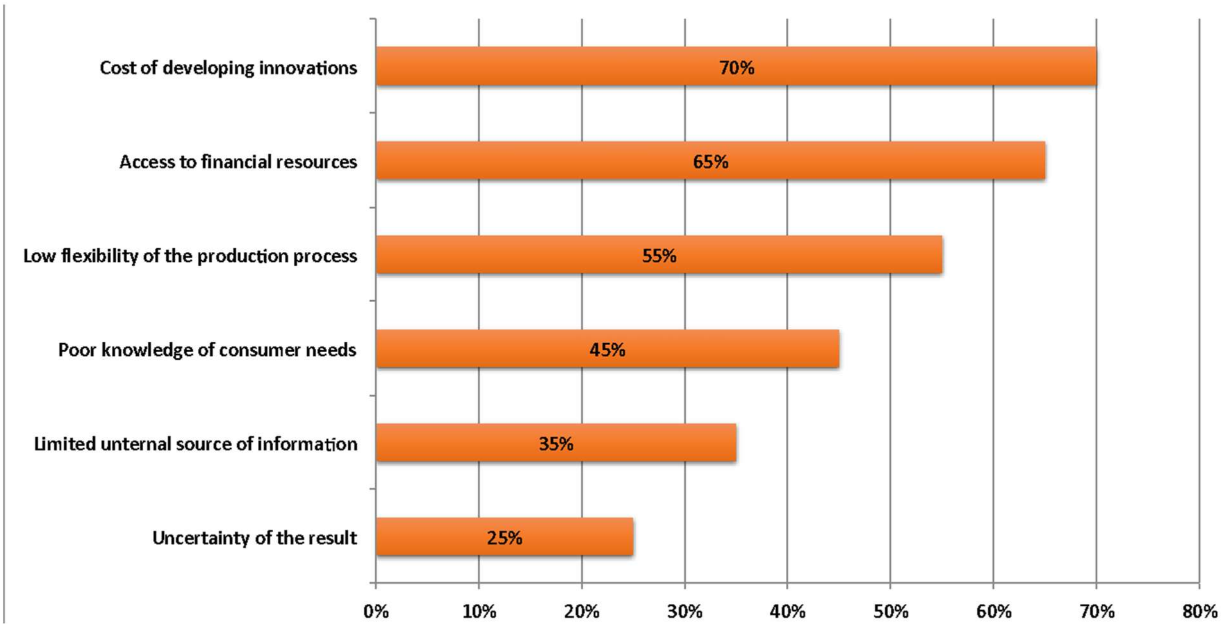

Figure 3. Barriers to develop innovations.

In terms of the role of packaging in containing and protecting F&D products, plastics seems to be the most used material (80%), followed by glass (40%), and paper and cardboard (35%). Multi-layer films as well as aluminium are instead the less common packaging materials, with a percentage of 20% and 10% respectively.

Moreover, all these companies considered the role of packaging in reducing FLW as well as minimizing the environmental impact of the packages important. In this context, most of the F&D manufacturers (65%) introduced packaging innovations to reduce FLW such as resealable packaging, adopted by 20% of these companies, smaller package size and with improved barrier properties, selected by 30% of these manufacturers. At the same time, 80% of the entrepreneurs developed packaging innovations to contribute to improving the environmental wellbeing. Specifically, they introduced reusable packaging (30%), 100% recyclable (45%), compact (35%) and flexible (5%).

In analysing the manufacturers' awareness about their packaging innovation' needs, most of the companies expressed the necessity to continue improving the packaging features (80%), as indicated in Figure 4.

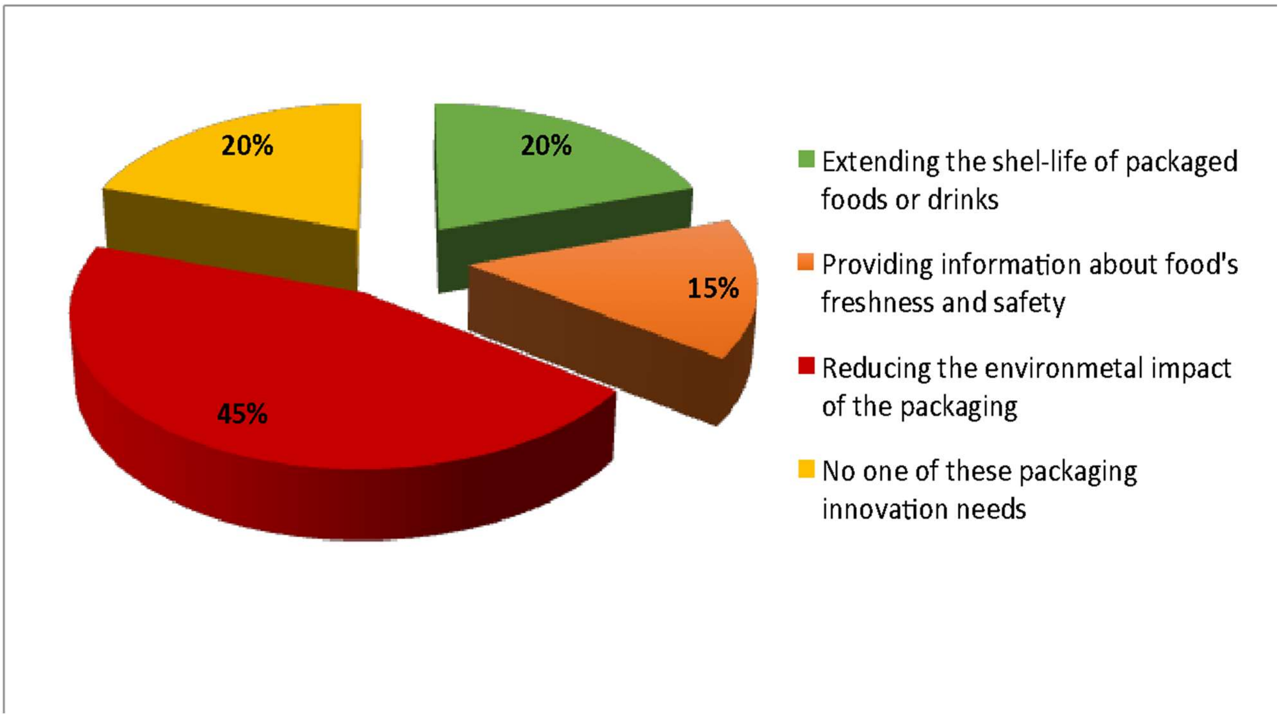

Figure 4. Packaging innovation needs.

With regard to the manufacturers' knowledge about the existing technological options to achieve their needs, results showed that all the companies were aware about compostable packaging. Conversely, 40% of the manufacturers and 25% were not aware about intelligent and active packaging, respectively. However, after providing them neutral information about these technologies, 75% of them declared to be willing to invest for one typology or even for all the proposed innovations (Figure 5).

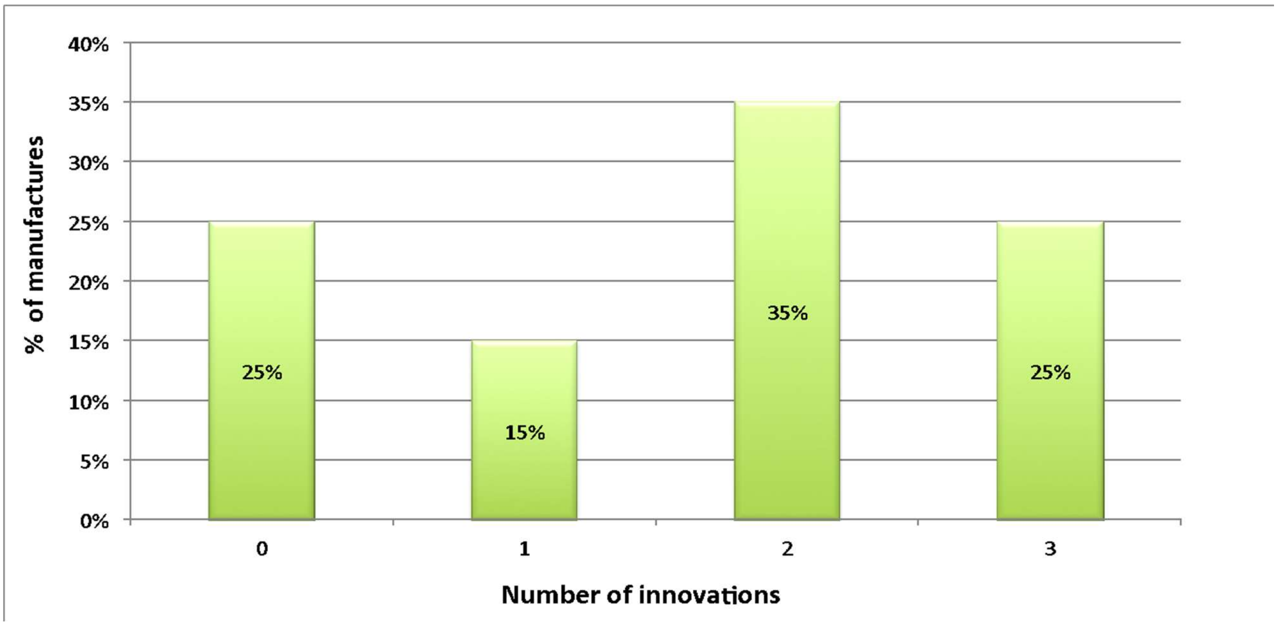

Figure 5. Number of manufacturers prompt to invest in one or more innovations.

4.1 Demand for active and intelligent packaging

By testing the demand for packaging innovation using the theoretical model, the following results were observed: 12 companies were willing to invest in active packaging. Moreover, all these F&D manufacturers considered active packaging important to enhance food safety and its shelf-life. They also, except for the Case M2, evaluated this technology as important to obtain competitive advantage. However, only two companies (Cases M1, M4) could be considered able to translate their needs in a packaging innovation, as shown in Table 3.

Table 3. Demand for active packaging

Cases	Business innovation need: "extend foods or drinks' shelf-life"	Awareness about active packaging	Firm's capacity to translate the need into a packaging innovation	Demand for active packaging
B1	Yes	No	Dependent	Latent
B2	No	No	Unconscious	Potential
B3	No	Yes	Unconscious	Potential
D3	No	Yes	Unconscious	Potential
F2	No	Yes	Unconscious	Potential
F3	No	No	Unconscious	Potential
F4	No	Yes	Unconscious	Potential
M1	Yes	Yes	Autonomous	Real
M2	No	Yes	Unconscious	Potential
M4	Yes	Yes	Autonomous	Real
W1	No	Yes	Unconscious	Potential
W4	No	Yes	Unconscious	Potential

On the contrary, ten companies declared to be willing to invest in intelligent packaging. They considered this technological solution important in reducing food waste and improving food safety. Moreover, they considered this technology important to obtain competitive advantage, except for Cases D2 and M4.

However, results showed that only one of these companies (Cases D2) could be considered to have a real demand for intelligent packaging, as exposed in Table 4.

Table 4. Demand for intelligent packaging.

Cases	Business innovation need: "Provide information about food's freshness and safety"	Awareness about intelligent packaging	Firm's capacity to translate the need into a packaging innovation	Demand for intelligent packaging
B1	No	No	Unconscious	Potential
B2	No	No	Unconscious	Potential
B3	No	Yes	Unconscious	Potential
D2	Yes	Yes	Autonomous	Real
D3	No	No	Unconscious	Potential
M1	No	Yes	Unconscious	Potential
M2	Yes	No	Dependent	Latent
M4	No	Yes	Unconscious	Potential
W1	No	Yes	Unconscious	Potential
W4	No	No	Unconscious	Potential

4.2 Demand for compostable packaging

12 companies were willing to invest in compostable packaging. The results show that only two manufacturers (Cases B2, M1) were willing to invest in plant-based compostable packaging such as plants that are rich in carbohydrates (e.g., corn, sugar cane) or plants that are not eligible for food or feed production. The other 10 companies (Cases B1, B3, B4, D3, F1, F2, F3, F4, M2, W1) preferred the use of FLW.

Moreover, all the 12 companies considered this technology important to reduce the environmental impact of the packages, with the exception of Cases F1 and F2, and to obtain competitive advantage.

Finally, results show that six companies could have a Real demand for compostable packaging, as shown in Table 5.

Table 5. Demand for compostable packaging.

Cases	Business innovation need: "reduce the environmental impact of the packaging"	Awareness about compostable packaging	Firm's capacity to translate the need into a packaging innovation	Demand for compostable packaging

B1	No	Yes	Unconscious	Potential
B2	Yes	Yes	Autonomous	Real
B3	Yes	Yes	Dependent	Real
B4	Yes	Yes	Dependent	Real
D3	Yes	Yes	Dependent	Real
F1	Yes	Yes	Dependent	Real
F2	No	Yes	Unconscious	Potential
F3	Yes	Yes	Dependent	Real
F4	No	Yes	Unconscious	Potential
M1	No	Yes	Unconscious	Potential
M2	No	Yes	Unconscious	Potential
W1	No	Yes	Unconscious	Potential

According to the adaptation of the authors to the theoretical model proposed by Muscio et al., (2010) [52] six companies were considered dependent on an external source of knowledge (e.g., University, Research institutes, suppliers) to develop packaging innovation. This is due to the lack on the market of compostable packaging made by FLW.

5. Discussions

According to the results of this analysis, most of the Italian manufacturers could be interested in the adoption of health and eco-innovations in packaging to reduce FLW.

This study, applied to 20 micro and SMEs located in Southern Italy, showed that manufacturers are aware about the important role of packages to avoid FLW as a tool to improve the environmental wellbeing as well as to obtain competitive advantage.

In this regard, companies have already started to introduce improvements in the packaging features with a particular attention to its design. Specifically, companies introduced 100% recyclable packaging, compact and flexible packages. Moreover, they opted for resealable packaging, smaller packages size and with improved barrier properties. In line with these results, Williams et al., (2020) pointed out that the most important packaging factors that affect household waste are size and label (display of the information about product safety and storage) [74]. Indeed, according to Wohner et al., (2019), packaging must contain the right amount of food, provide information and convenience features for the consumers, such as easy to use, resealability and easy to empty [75].

Furthermore, F&D manufacturers expressed the need to continue improving the packaging features. Most of the companies (45%) highlighted the necessity to "reduce the environmental impact of the packaging"; 20% of the manufacturers to "extend the shelf-life of packaged foods or drinks"; and 15% to "provide information about food's freshness and safety". The remaining part (20%) did not express any specific packaging innovation needs.

Moreover, companies were also aware about the technological opportunities to meet their needs, most of them about compostable packaging. Conversely, 40% of the manufacturers and 25% were not aware about intelligent and active packaging, respectively. However, after providing them neutral information about these technologies, 75% of the interviewed declared to be willing to invest in at least one packaging innovation. The technological solutions most preferred by the companies were both active and compostable packaging (60%). Intelligent packaging was the least preferred technology, selected by 50% of the firms.

Finally, this study showed that only the F&D manufacturers who have presented a real demand for innovation are effectively prompt to invest in this field. In testing the demand for packaging innovation, through the theoretical model proposed by Muscio et al., (2010), most of the manufacturers (68%) expressed only a potential demand for innovation, since they did not show a clear understanding of the packaging needed to be improved. Latent demand for innovation (6%) was mostly found for active and intelligent packaging. In this case, companies showed to be aware about their packaging innovation needs but they did not have a clear technological solution in mind to address this need. Furthermore, 26% of the F&D manufacturers expressed a Real demand for packaging innovations, 67% accounting for compostable packaging.

With respect to this latter, most of the companies (83%) showed a particular emphasis on recovering FLW for the production of biopolymers for eco-innovations in packaging. However, despite the vast evidence provided in literature regarding the concrete possibility to produce compostable packaging using FLW, their presence on the market is scant. For this reason, companies were considered dependent on an external source of knowledge (e.g., University, Research institutes, suppliers) to develop packaging innovation. Moreover, the lack of high-skilled staff as well as low investment rate in R&D are considered barriers for the internal development of innovations, as also pointed out by Avermaete et al., (2004) and Muscio et al., (2016) [47,48]. In contrast with Simms et al., (2020), the manufacturers didn't highlight the lack of consumer demand as a barrier to innovate [66]. Finally, as confirmed by Fonseca et al., (2018) and Keränen et al., (2020) there is the need to improve the collaboration among all the actors of the FSC in order to switch from a liner economy to a circular economy [36,67].

6. Conclusions

This study provides useful information for both producers and policy-makers in the agro-food sector about their willingness to invest for health and eco-innovations. Given the presence of very few existing studies on this topic, these results surely fill the gap in scientific literature, contributing to improving the research in this field. Specifically, the paper provided a complete analysis about the key drivers and barriers affecting the micro and SMEs' willingness to invest for both health and eco-innovation innovations. The main results show that most of the interviewed manufacturers are willing to invest in at least one packaging innovation, choosing mainly between the active packaging and the compostable one.

Additionally, the overall results of the study have several practical implications. The study highlights that many companies do not have a clear understanding of their needs regarding packaging innovations; this finding underlines the importance of the definition and emersion of potential and latent demand for innovation and of the role of bridging institutions (TTOs, technology poles, etc.) and collaborations between research institutions and industries. The results could lead to market implications such as the production costs, the complexity of these technologies as well as the consumers' acceptance. Finally, the study involves policy implications through the use of packaging as a tool to promote environmental sustainability, responsible production and consumption.

The limits of this study are related to the sample size, the geographic settings, as well as the economic activities. Specifically, the main limitation is linked to the few numbers of enterprises involved in the survey (20). Thus, this research could be taken as a reference for broader application at the national level and in other food markets. This could highlight differences due to resource endowments and firms' internal capabilities, as well as policy, structural or cultural issues.

Suggestions for further research could be the evaluation of consumers and producer's perception of hazards related to packaging in particular materials in direct contact with food, also focusing on the European regulation concerning the risk management related to the potential toxicity of some materials. Such a study would make it possible to investigate the level of knowledge and the actual need for information to ensure food safety and consumers' health.

Appendix A

Table 1 - The questionnaire's structure

Section	Questions	Response kind	Response option
1. *Company's identification data*	Company name	Open-ended	text
	Legal form	Open-ended	text
	Province	Open-ended	text
	Year of establishment	Open-ended	numeric
2. *Business details*	Company' size	Polytomous	micro, small, medium
	Family business	Dichotomous	yes/no
	Agricultural enterprise	Dichotomous	yes/no
	List of sold products	Open-ended	text
	Distribution channels	Multiple	GDO, Ho.Re.Ca., specialized shops, direct sales, e-commerce.
3. *Human resources*	Number of employees	Open-ended	numeric
	Number of graduate employees	Open-ended	numeric
	Participation in continuing education programs	Dichotomous	yes/no
4. *Weaknesses and strengths*	Functional area that represents weakness and strength	Polytomous	Production, logistics, sales, marketing, account, finance, human resources, R&D
5. *Innovation*	Investment in R&D during the last three years	Open-ended	numeric
	Main barriers for the development of innovation	Multiple	Cost to develop innovations, access to financial resources, low flexibility of the production process, poor knowledge of consumer's needs, lack of internal source of knowledge, uncertainty of the result
	Importance of external source of knowledge (e.g., University	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important)

	and research institutes) to develop innovation		
6. F&D packaging	Role of packaging to reduce FW	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important)
	Role of packaging to reduce environmental issues	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important)
	Packaging innovations adopted to reduce FW	Multiple	Resealable packaging, smaller packaging, improved barrier properties, no one packaging innovation
	Packaging innovations adopted to reduce the environmental impact of the packaging	Multiple	Smaller packaging, 100% recyclable packaging, reusable packaging, no one of packaging innovation
	Packaging needs	Polytomous	Extend the shelf-life of packaged foods or drinks, provide information about food's freshness and safety, reduce the environmental impact of the packaging, no one of these needs
7. Willingness to invest for intelligent packaging	Knowledge about intelligent packaging	Dichotomous	yes / no
	Preferred technology	Polytomous	Freshness indicator, Leak indicator, Time-temperature indicator, Temperature indicator, gas sensor.
	Importance of this technology to obtain competitive gain / to reduce food waste / to improve food safety	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important)
	Willingness to invest for intelligent packaging	Likert scale	7-point Likert scale ranging from 1 (not willing at all) to 7 (extremely willing)

8. Willingness to invest for active packaging	Knowledge about active packaging	Dichotomous	yes / no
	Type of active packaging preferred	Polytomous	Active substances into the packaging material, active substances into sachets/labels.
	Preferred technologies	Multiple	Antimicrobial packaging, antioxidant packaging, carbon dioxide releasers, ethylene scavengers, improved UV-light barrier, moisture scavengers, odor and flavour scavengers, oxygen scavengers
	Importance of this technology to obtain competitive gain/to reduce food waste/to improve food safety	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important).
	Willingness to invest for active packaging	Likert scale	7-point Likert scale ranging from 1 (not willing at all) to 7 (extremely willing)
9. Willingness to invest for compostable packaging	Knowledge about compostable packaging.	Dichotomous	yes / no
	Preferred raw material	Polytomous	Plant based (corn, sugar cane); made from FLW
	Importance of this technology to obtain competitive gain / to reduce the environmental impact	Likert scale	7-point Likert scale ranging from 1 (not important at all) to 7 (extremely important)
	Willingness to invest for compostable packaging.	Likert scale	7-point Likert scale ranging from 1 (not willing at all) to 7 (extremely willing)

Table 2. General characteristics of the companies interviewed.

Variable	%
Firm' size (expressed in terms of number of full-time employees and turnover class)	

Micro	25
Small	40
Medium	*35*
Agricultural firms	**30**
Family Business	60
Multilocalized	20
External management	10
Graduate employees	**22**
Distribution of Sales	
Regional	*33*
National	41
Foreign	26
Investments in R&D as percentage of the sales (during lasts 3 years)	
0%	30
0.1 – 1%	50
1.1 – 2 %	5
2.1 – 5%	5
5.1 – 10%	10
Product innovations (during lasts 3 years)	**85**
Point of weaknesses	
Administration and finance	*15*
Logistics	*25*
Personnel management	*10*
Production	*10*
Research and Development	*25*
Sales and marketing	*15*

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GENERAL CONCLUSIONS

Packaging is a key element of the Food Supply Chain (FSC), which determines maintenance of the food product quality, integrity and safety. Its main role is the protection of foods from contamination, external environment and mechanical damage during transport. Therefore, deficient packaging material is considered one of the main causes of the generation of food loss and waste. However, packaging also affects the environment in a negative way polluting our soil, air and oceans.

In this context, the improvement in ecological concerns and the consumer's demand for healthy and sustainable products, as well as the need to achieve the new targets of the 2030 Agenda by the United Nations (UN), has led food and drink companies to develop innovative packaging solutions with food safety enhanced level, extended shelf-life properties and as well as made with environmentally sustainable materials.

Such research leads to the development of active, intelligent and sustainable packages. Active packaging refers to the incorporation of chemicals into packaging material to improve food quality and safety and therefore extending the shelf-life. The intelligent package, instead, allows monitoring of food products' quality through the packaging as it reacts with the surrounding environment during transportation and storage phases displaying the quality level of the product when the product reaches the consumer. Further, other technological innovations in the packaging area mainly focus on developing new materials to create sustainable packaging which minimize the plastic waste and their environmental impact. For instance, bioplastics are driving the evolution of plastics. There is one important advantage of biobased plastic products compared to conventional versions: they save fossil resources by using biomass which regenerates (annually). Then, bioplastics are made from plants that are rich in carbohydrate, such as corn or sugar cane, or from ligno-cellulosic feedstocks (plants that are not eligible for food or feed production). Moreover, the technological innovation in this area is focused on the use of organic waste feedstocks such as the use of the whey, the by-product of the dairy industry.

In the light of these premises, the aim of this thesis was twofold. First, it was to explore whether consumers are willing to purchase food products packaged with innovative solutions such as active, intelligent and sustainable packaging, as well as to define the determinants of their intentions. Secondly, it was to investigate if the food and drink manufacturers are willing to invest in such packaging innovations.

Results from the aggregate analysis of the literature showed that consumer's willingness to purchase and to pay for innovative packaging was strongly affected by the consumer's knowledge about these technological solutions. Moreover, consumer's willingness to purchase active and intelligent packaging was influenced by the perceived risks for human health. Thus, consumers seemed to be more willing to purchase intelligent packaging rather than the active one as consumers believed to have more control over such technology as well as they believed that this technology does not interfere with the food product. Finally, the analysis of the evidence presented in literature also showed that consumers were willing to purchase and to pay for sustainable packaging, such as biodegradable and compostable ones, to protect the environment.

These results were also supported by the empirical case study on 260 Italian consumers highlighting that consumers were willing to purchase active and intelligent packaging to lower household food waste. Specifically, attitudes, perceived behavioral control, awareness as well as planning routines were the most important drivers of the intention to reduce household food waste. Finally, also in this case, consumers were more willing to purchase intelligent packaging rather than the active one to reduce their wastes generated at home, thanks to the ability of this package to provide real-time use-by or expiration data.

Furthermore, the empirical case study on 260 Italian consumers also showed that consumers were willing to purchase sustainable packaging to protect the environment, preferring more the use of plant-based feedstocks (e.g., corn, sugarcane etc.). Indeed, the use of organic waste feedstocks (e.g., whey) for food packaging applications was perceived as potentially risky for human health. Moreover, pro-environmental attitudes, perceived control over the individual actions (e.g., recycling), the social pressure to preserve the environment as well as the consumer’s awareness for the environmental issues were the main drivers of the personal intention to purchase sustainable packaging for foods, and thus for milk. Finally, regardless of the renewable origin of the raw material, consumers were also willing to pay 1% - 5% more for milk within biodegradable packaging.

Findings from the multiple case study on 20 micro, small and medium-sized enterprises (SMEs), located in Apulia region (Italy), showed that most of the interviewed manufacturers were willing to invest in at least one of the packaging innovations, mainly preferring between the active packaging and the sustainable one. However, most of these companies seemed to be dependent from an external source of knowledge to introduce packaging innovation into the market.

This research work provided useful information about those food packaging innovations predicted to play an increasingly important role in the upcoming years. Moreover, this could be considered the first attempt to summarize and collect the evidence from the literature from both consumers and manufacturers point of view, contributing to expanding the current knowledge about this topic. Then, the results obtained from the aggregate analysis of the literature as well as from the empirical case studies may have important policy and marketing implications.

Policymakers and companies may develop informational campaigns to increase the level of consumers’ knowledge about active, intelligent and sustainable packaging to encourage their adoption among consumers. Indeed, the successful implementation and commercialization of these innovations depends on the development of policies to promote such packaging solutions in order to increase consumer’s perceived benefits. Furthermore, policies such as informational and education campaigns should also try to increase the level of consumer’s awareness about the negative impact of food waste and packaging waste on the environment, and thus for human health, being an important driver of the personal intention to purchase such technological solutions. Additionally, companies may also promote with marketing campaigns the use of the whey, as totally safe food contact material, to create biodegradable packaging, considering that this by-product of the dairy industry is commonly used to produce food supplements (e.g., whey proteins). In this regard, policymakers should also encourage, with incentive based-policy (e.g., tax relief), companies to reuse the whey for the production of value-added products to increase the efficiency of the dairy industry and adopt closed-loop recycled systems.

Finally, to facilitate the emergence of a real demand for packaging innovations among micro and SMEs there is the need to increase the collaboration between universities, research institutes and industries as well as between all the actors of the FSC in order to implement circular economy strategies.

La Borsa di Dottorato è stata cofinanziata con risorse del
Programma Operativo Nazionale Ricerca e Innovazione 2014-2020 (CCI 2014IT16M2OP005),
Fondo Sociale Europeo, Azione I.1 “Dottorati innovativi con caratterizzazione Industriale”

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