Mismatch between food sustainability and consumer acceptance toward innovation technologies among Millennial students: The case of Shelf life extension

1. Introduction

In the last decades, modern food systems have been faced with a challenge to accelerate the shift towards sustainable development and production, identifying solutions that are able to enhance productivity and sustainability along the supply chain while helping the sector cope with climate change issues (OECD, 2012). The transition towards new models of food production and consumption will depend on the sector's capacity to introduce innovative approaches and strategies at any level of the supply chain (Schiefer and Deiters, 2016). Nonetheless, compared to other manufacturing sectors, the food and drink sector in Europe is low innovation and only the 1.9% of the EU patent applications were related to such products (Eurostat, 2012)[1]. In the food sectors, ready-made meals are the most innovative, with 8% of the total European food innovation, followed by dairy products (7.5%), soft drinks (6.3%) and savory frozen products (6.2%) (FoodDrinkEurope, 2016). Moreover, in addition to patent data, research and development (R&D) expenditures can also be used as a measure of innovation. Data revealed that the low levels of R&D expenditures at an aggregate level and the low propensity for the development of new knowledge led to considering the European food and drink sectors as low-tech industries (de Almeida Costa et al., 2016).

The capacity to innovate represents a strategic tool for firms to maintain a competitive position in the marketplace (De Jong et al. 2006; Laforet and Tann, 2006). This is particularly relevant in the Italian market, where small and medium enterprises (SMEs) represent a greater part of the food industry (Spillan and Parnell, 2006; Banterle et al., 2016): the introduction of new ideas, processes and products allows SMEs to survive alongside big enterprises and to face the growth of competition due to globalization processes (Traill and Grunert, 1997). On the demand side, consumers are increasingly careful about what they eat, as a consequence of problems related to food intolerance, allergies and episodes of food poisoning and scares (McEachern and Schroder, 2004; Grunert, 2005; European Commission, 2007), along with the increased awareness of the existence of a direct link between diet and health (Bui and Fazio, 2016). In this context, despite the fact that technological innovation in the food chain can play a strategic role in coping with the evolution of the consumers' needs and choices, evidence suggests that consumers tend to appreciate technology applications in general and, conversely, find food technologies risky (Lusk et al., 2014).

As a consequence, the academic interest towards food products produced with innovative technologies has increased and a specific attention has been paid on the factors that could explain consumer acceptance or skepticism with regard to these new technologies (Biltekoff, 2010; Magnusson and Hursti, 2002; Verneau et al., 2014). Moreover, for the specific case of Italy, Eurobarometer data show the lowest percentage of respondents who think that both science and technological innovation as well as people's actions and behavior will have a positive impact on the availability and quality of food (Ebs, 2014). In addition, the highest proportion of respondents who consider food origin as important can be found in Italy. Indeed, almost 70% of the respondents are aware and interested in the Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) logos (Ebs, 2012). This is the peculiarity of the Italian

[1] Several indexes have been employed to measure the technological changes based on patents (Daim et al., 2006). Indeed, the number of patents reflects inventive activity and innovation and could be considered a good proxy for evaluating the evolution of technology in a particular area (Pantano et al., 2017). A patent is described as a 'source of technical and commercial knowledge about technical progress and innovative activity' (Park et al., 2005) and is the most used tool to protect inventions (Archibugi and Pianta, 1996).

population, which translates to a great preference for high quality, typical, and niche food productions and a high adherence to ‘Made in Italy’ products (Ebs, 2012).

In this frame, the aim of this work is to analyze the factors that affect consumer acceptance towards new technologies in food with a special focus on Shelf Life Extension, which is considered to be one of the most sustainability-driving food innovations. Plenty of studies have focused on new innovation technologies in the food sector, such as bio-fortified food, nanotechnology, and transgenic food, but, to our best knowledge, the acceptance of Shelf Life Extension technologies has never been investigated (Bieberstein, et al., 2013; Magnusson and Hursti, 2002; McFadden and Lusk, 2014; Stevens and Winter-Nelson, 2008; González et al., 2009; Vandermoere, et al., 2010).

The target group for the analysis is represented by the Millennial Generation (MG), in particular, the college student category of the MG, aged 20-25 years old. The MGs are considered more knowledgeable than others with respect to the environment, and they are more global and community oriented and less brand-loyal (Harris et al., 2011). They are also more concerned about the environment and the ethical attributes of products (Gustin and Ha, 2014; Schubert et al., 2010; Sloan, 2014). This generation plays an important role in terms of emerging purchasing power, and the comprehension of their preferences and behaviors could predict future food choices and trends.

This paper is structured as follows: the next section presents the main characteristic Shelf Life Extension technology, and section 2 describes the conceptual framework followed in this study. Moreover, the third section explains the details of data collection and the methodology applied; the fourth section provides the results and discussions. Finally, the study’s conclusions and limitations are presented in the fifth section.

1.1 Why the Shelf Life Extension?

Shelf life is the period of time before a food product is considered unsuitable for consumption or sale. During the last several years, reliable methods have been developed to extend the shelf life of food products through formulation, processing or packaging innovations (Soliva-Fortuny and Martín-Belloso, 2003; Deegan et al., 2006; No et al., 2007; Odueke et al., 2016; Banerjee et al., 2016). Active packaging and modified atmosphere packaging are widely used as a supplement to refrigeration to delay spoilage and extend the shelf life of fresh products while maintaining a high-quality end-product. The most recent innovation in this sector introduced the adoption of ‘mild’ technologies that are able to preserve the nutritional and organoleptic characteristics of food products. In these recently developed innovations, antimicrobial compounds can be incorporated into the packaging films or coatings in order to maintain high concentrations of preservatives on the surface of foods for a longer storage time (Chouliara et al., 2007; Yuan et al., 2016). A chitosan coating forms a semipermeable film on the surface of fruits and vegetables, thereby delaying the rate of respiration, decreasing weight loss, maintaining the overall quality, and prolonging the shelf life (Romanazzi et al., 2017). Natural food preservatives can help in ensuring protection from both spoilage and pathogenic microorganisms and are achieved by using low concentrations of essential oils in combination with other preservation technologies, such as low temperature (Scandamis and Nychas, 2001), low dose irradiation (Farkas, 1990; Chouliara et al., 2005), high hydrostatic pressure (Devlieghere et al., 2004) and modified atmosphere packaging (Marino et al., 1999).

The extension of the shelf life of food products is considered a possibly positive contribution to improving the overall sustainability of a food product along its entire supply chain. Indeed, this technology can help in counteracting food waste, which is responsible for 17% of direct greenhouse gas emissions and 28% of material resource use (Priefer et al., 2013). A recent EU Resolution (European Commission, 2010) states that food gets wasted in approximately 89 million tons per year throughout the entire food system from households (42%), manufacturers (39%), retail (5%), and catering (14%): there is a potential for the spoilage of food products at any stage of the supply chain when the products reach their ‘best before’ or ‘saleable date.’ As a key to the food waste problem, there is a trend towards developing Shelf Life Extension solutions that are intended to allow products to facilitate supply chain management by reducing the production and delivery lead times, thus increasing the low predictability and stability of the supply logistic strategies (Amani and Gadde, 2015). For consumers, the positive impact of Shelf Life extended products relies on improved convenience attributes in response to consumer demands for less time spent on shopping and cooking. Moreover, the longer shelf life period should increase the consumer’s ability to manage food provision, storage, and preparation and, consequently, minimize domestic food waste.

2. Consumer Acceptance of New Food Technologies

Relatively little is known about the consumer’s perception and acceptance of Shelf Life Extension, although new food technologies have already been intensively investigated. Summarizing the main evidence on the various topics driving the controversies around new food technologies, *trust* represents one of the main important factors (Cost Font et al., 2008; Vandermoere et al., 2010). Indeed, food neophobia, described as the propensity to avoid new foods, can also be a consequence of the lack of social trust. From a theoretical point of view, trust represents a tool for reducing complexity and dealing with risk (Luhmann, 2000). Another factor that can influence the benefit-risk perception is *media coverage* (Fox et al., 2002; Roosen et al., 2011). The media aims to communicate and translate new science to consumers. Food scares and worries are examples of how the media can sway the public’s perceptions of risk. Nevertheless, it would be erroneous to blame the media for the public’s unbalanced responses to such events, even though their influence is important and sometimes detrimental to the public’s understanding.

Also, *cultural cognitions* and *worldviews*, including food values (in particular, naturalness) have been studied in relation to the acceptance of new food technologies (Lusk and Briggeman, 2009). Indeed, the consumer’s general cultural and political attitudes toward the world influence how technologies are perceived by individuals and how the individuals evaluate them (Douglas, 1990; Dake, 1991; Peters et al., 2004; Slovic, 1999). In terms of technology acceptance and risk perception, people’s acceptance of a technology depends on how the potential risks are managed against the background of the individual’s view of the organization of society (Peters and Slovic 1996). If the relationship between the *familiarity* with the new technology (Macoubrie, 2004; Bieberstein et al., 2013) and consumer acceptance is proven, for a relative lack of knowledge, the results are controversial. Indeed, simply informing consumers that a technology as safe may not help the consumer accept the technology (McFadden and Lusk, 2014).

Among these factors, this work focused only on those that could be strictly referred to as the acceptance of a specific case study of Shelf Life Extension technology and on those that characterize the Millennial student sample.

The first aspect is referred to as *consumer interest in sustainable practices*. In other words, a sustainable behavior could lead to the acceptance of a food technology, such as Shelf Life Extension, because of its sustainability implications. For example, Niva et al. (2014) found that sustainable food consumption is related to interests in cooking and healthy food choices, confirming that an environmental attitude is acquiring great influence on consumers’ food-related behaviors. Matin et al. (2012) revealed an inverse relationship between environmental attitudes and nanotechnology acceptance, as confirmed by Vandermoere et al. (2011), who stated that public perceptions of technologies in the food domain significantly relate to universalistic values (Grunert and Juhl, 1995; Thøgersen and Ölander, 2002; de Boer et al., 2007). Among these values, ‘naturalness’ is identified as a choice motive that motivates a consumer’s preference for unaltered foods (o’Connor et al., 2005; Ares and Gambaro, 2007; Rozin, 2012) over innovative and new products.

Also, *food knowledge* can play an important role in driving the perception of Shelf Life Extension products. Several studies state that knowledge could represent a useful tool for helping consumers make more informed and aware food choices, leading to higher levels of acceptance. Thus, food knowledge could be essential to shaping consumer attitudes (Boccaletti and Moro, 2000; Villela-Vila et al., 2005; Allum et al., 2008; Simon, 2010) and their dietary choices by having a direct effect on the performance of complex tasks (Miller and Cassady, 2015, Spronk et al., 2014; Bonsmann and Wills, 2012; Campos et al., 2011; Hieke and Taylor, 2012; Lähteenmäki, 2013; Wills et al., 2012). In this sense, a higher level of food knowledge could mean a higher level of understanding of technology and a major level of acceptance.

Another factor that could increase acceptance is represented by *education*. Indeed, education is considered one of the most important determinants of public attitudes. Bak (2001) evidenced that levels of education and levels of scientific knowledge make independent contributions to public attitudes toward science. A further contribution is provided by the university curricula, as noted by the work of Rodríguez-Entrena and Salazar-Ordóñez (2013), who evidencing some differences in behavioral intentions towards GM food between scientific-technical and social-humanistic literacy fields.

3. Research Methods

The selection of MG students as the target group for research relies on the fact that they will be the consumers of the future, they are more inclined to get involved in environmental issues, and they are more willing to change their behaviors (Lozano et al., 2013; Vicente-Molina et al., 2013; Zsóka et al., 2013). Within this group, to evaluate the role of different university curricula, student samples were composed of 50% social sciences and 50% applied sciences. The master degrees of the University of Milano were listed in order to identify and group the social and applied science degrees. Moreover, the head of the teaching board of each degree was contacted to ask for the willingness to participate in the survey. Within the offered degrees, in order to consider different levels of food knowledge, applied science students belonging to Food Science, Pharmacy and Engineering degrees were recruited. Within the social sciences, the degrees in Humanities, Law and Political Science were selected.

The sample size (approximately 1000 students) was decided following the criterion explained by Mazzocchi (2008) for the determination of the relative accuracy of a mean estimator according to both the sample and population sizes (choosing a level of error of approximately 3%).

Data were collected during April and May 2016 through a face-to-face survey of the Millennial Generation students, using an ad hoc questionnaire. The respondents were assured of anonymity and confidentiality. The data were collected from the students during the class hours of the universities in order to reduce the refusals to participate. Students who declined participation were replaced by other students. The answering time for the questionnaire was approximately 15–20 min. The questionnaire consists of 66 questions and is structured in different sections. The order of appearance of the sections has been randomized to avoid the bias that can result from the order that the items are presented in the questionnaire.

The first question that the respondents were asked to answer related to their shopping habits, namely, if they are the main person responsible for food purchases, and only respondents who answered positively to this question were included in the survey. Excluding all incomplete observations from the analysis, the final sample was composed of 1027 respondents.

The first section of the questionnaire focuses on individual attitudes toward food technology applications in general. A validated scale on Food Technology Neophobia, developed by Cox and Evans (2008), was employed in order to

determine the respondents' fear of novel technologies in food products (pasteurization, high pressure, genetic modification). The Food Technology Neophobia Scale (FTNS) represents an evolution of the previous Food Neophobia Scale (FNS) proposed by Pliner and Hobden (1992). In a further work of Evans et al. (2010), the FNTS is confirmed as a reliable and predictive measure of responses to novel food technologies. Two bilingual translators translated all of the original items from English to Italian. Subsequently, a third bilingual translator back-translated the Italian version of the scale into English. The differences found were resolved by discussion, with all the translators agreeing on the final versions of the two scales (Schnettler, et al., 2016; Sousa and Rojjanasrirat, 2011) (Annex A). For the 13 items of the FTNS, respondents had to indicate their level of agreement using a Likert 7-point scale (Cox and Evans, 2008).
The second section of the survey contains questions meant to elicit the respondent's level of food knowledge, adapted from Parmenter and Wardle (1999). The validated scale on food knowledge collects information on knowledge about nutrient content, diet related diseases, dietary recommendations and choices in everyday foods. For each question, a correct answer was assigned the value of 1 and a wrong answer was assigned a value of 0, with a total score ranging from 0 to 30.
The third section is dedicated to eliciting the consumer's degree of sustainability in food consumption (SFC) through the index developed by Niva et al. (2014). The scale represents a summative index of 6 statements concerning the consumption of locally produced foods, seasonal fruits and vegetables, and organic foods and limits the consumption of meat, products with excessive packaging and food products imported by airplane. This measure was employed as a proxy to measure the consumer's environmental sustainability concerning good practices in food consumption.
Section 4 addresses a focus on consumer acceptance toward the new technology of Shelf Life Extension. It contains a preliminary question on familiarity with the specific technology. The aim of this question was to understand the level of familiarity with regard to this food technology without any kind of information received. Furthermore, to avoid potential bias, because some respondents could ignore the technologies of Shelf Life Extension, a brief description of the main characteristics of this technology has been provided: '*Shelf life of a food product can be defined as the time in which the product remains acceptable on the shelves. There are a set of technologies under development that will allow the extension of the shelf life of food products, thus reducing the frequency of provisions and waste.*' After the information, they were asked questions about their willingness to try foods using the technology under study (expressed as dummy). Moreover, a set of questions focused on specific case studies (poultry meat, bread, fresh-cut salad, mozzarella cheese, and fish fillets[2]) were provided, meant to elicit, for each of them, the degree of consumer preferences for two different Shelf Life Extension time ranges. For each product, the students were asked to respond on a graphical continuous rating scale from 0 (not at all) to 7 (very much) by making a sign on a bar.
Moreover, as in the Eurobarometer survey, two questions were employed on the public perception of science, research and innovation (Ebs, 2014). These questions have been used as a proxy for the level of the respondent's confidence in both the impact of people's action and science on the quality and availability of food in the next years.
The last part of the survey focuses on socio-demographic characteristics (age, gender, education).
Tab. 1 presents the descriptive statics of all the variables mentioned above.
The investigation of the respondent's acceptance of Shelf Life Extension Technology has been performed through a multiple-level data analysis that is able consider different aspects and variables. To summarize the information on the statements composing the FTNS scale, the first step consisted of a principal component factor analysis with a Varimax

[2] The choice of the products is linked to the project on which this paper was developed. Indeed, the project, titled 'Long Life, High Sustainability,' analyses specific case studies in order to combine the technology of Shelf Life Extension with a possible increase in the global sustainability of a food product from farm to fork.

rotation to allow the extraction of components that are highly correlated and to obtain more interpretable factors. Second, a set of OLS and logit regression (seven models) are performed. All models employed the same independent variables: food knowledge, familiarity with Shelf Life Extension, education, SFC index, Eurobarometer questions on people impact and a Eurobarometer question on science and technological innovation impact (transformed as dummy variables). The dependent variable in model 1 is Food Technology Neophobia. This variable represents the sum of all the values of the 13 statements that compose the scale (with the pro-technology statements reversed before summing). The second to sixth models are OLS regressions and the dependent variables are represented by the willingness to try a specific food product (mozzarella, poultry, sea-bream, fresh cut salad, white bread) whose shelf life has been extended. The last model is a Logit regression that uses a dummy variable about a general willingness to try Shelf Life extended food products as a dependent variable. The variance inflation factor (VIF) was calculated in order to avoid multicollinearity problems among the explanatory variables. In the analysis, the VIFs were always far below the problematic value of 5, meaning the absence of multicollinearity (Hair et al., 2011, 2016). Successively, in the specific case studies, a paired t-test was performed to test if technology acceptance is influenced by the rate of Shelf Life Extension (low and high extension period). For this step of analysis, the different levels of familiarity were considered by creating two sub-samples according to the revealed level of familiarity (familiar vs. not familiar).
Finally, a k-means cluster analysis (MacQueen, 1967) was utilized to determine the segmentation of respondents and to profile the consumers in order to verify the existence of different groups based on food technology perception. All reported analyses were conducted in IBM SPSS Statistics.

HERE, TAB. 1 DESCRIPTIVE STATISTICS

4. Results and Discussion

4.1 FTNS and SFC Index

The distribution of the FTNS in the sample is notably similar to the original scale proposed by Cox and Evans (2008), and the value for Cronbach's alpha is 0.76, showing good internal reliability. The millennial student sample showed slightly lower mean values (49.5 vs 55 on the original scale), probably due to their intrinsic characteristics. Indeed, the selection of students as a target group needs to take into account their greater familiarity with innovation and technology in general (Chung et al., 2010). Nevertheless, items 7 (*new food technologies are unlikely to have long term negative health effects*, reversed) and 13 (*the media usually provide a balanced unbiased view of new food technologies*, reversed) revealed an opposite trend, characterized by higher levels of concern for the potential impact of food technologies on health and a general mistrust about the quality of media information. The principal component factors analysis of the participant responses to the 13 items was performed (Tab. 2). The results of the Kaiser-Meyer-Olkin test and Bartlett's sphericity test showed adequacy of the sample for factorial analysis. The principal components analysis with a Varimax rotation showed four distinct factors that explained 56.8% of the total variation of the data. The factors resulting from the analysis reflect the output of Cox and Evans (2008); thus, the same names for each of them have been used. The first factor called, 'New food technologies are unnecessary,' includes all statements that are related to the feelings and worries about the risks of new food technologies and their uncertainty. The second factor, labelled 'Healthy choice,' is positively associated with the benefits in terms of the health of new food technologies. The third component adds different nuances to the aversion to new technology in food products. In this factor, labelled 'Perception of risks,' the aversion is associated with expected environmental impacts. Finally, the fourth component is strongly associated only to the statement, 'The media usually provide a balanced and unbiased view of new food technologies.' This factor is labelled 'Information/media.' Among the studies that have described the FTNS with a principal component factor analysis, the most similar results are those of Verneau et al. (2014), which equally refer to an Italian sample.

HERE, TAB. 2 FOOD TECHNOLOGY NEOPHOBIA SCALE

The results regarding the Sustainability of Food Consumption index reveal that the level of environmentally fair practices is quite high among the sample: for five out of the six activities considered by the index, almost half of the respondents reported practicing them already (Tab. 3). This could be explained by different factors: first, the Italian population shows a growing appreciation for agriculture with less environmental impact or are practiced with methods that ban synthetic chemicals (like organic) and are very attentive toward food products with schemes of geographical indications (like PDOs and PGIs). Second, the fact that millennials have been already identified as a more sustainable and environmentally friendly generation. Third, the role of education level could contribute to explaining this positive attitude toward sustainability. Indeed, as noted by Niva et al. (2014), people with a master level education stand out as being more active than those with only a basic education. Thus, the Italian millennial student sample used in this study effectively synthetized the abovementioned characteristics.

HERE TAB. 3 SUSTAINABILITY OF FOOD CONSUMPTION

4.2 Estimation results

To analyze the factors that are related to the food technology acceptance in general and in the specific case of Shelf Life Extension technology, 7 models are performed. The regression outputs highlighted no significant results for the variables Ebs_people impact or Ebs_sci&tech impact (all values showed p-values >0.05). A further regression was performed with the remaining variables and the final restricted estimation model (n=4) is shown in Tab. 4.
Model 1 confirms the recent literature, revealing the important role of food knowledge on the acceptance of innovation in food technology. The association between the two variables is significant and negative (-0.321); in other words, people with a high level of food knowledge are those more prone to accepting new technologies in food products, or are less neophobic. Indeed, studies have found high hostility to new technologies among consumers with low schooling due to their lack of knowledge about this topic (Vidigal et al., 2015). Also, genetically modified foods and their acceptance seems to be higher among people with higher knowledge (Moerbeek and Casimir, 2005; Vilella-Vila et al., 2005).
The results concerning the role of education reveal the strongest relation with FTNS (-3.115), revealing that those students attending applied science faculties are, *per se*, more inclined to accept innovation in foods than humanities students. This probably means that the type of university education can be interpreted as a proxy for a more general disposition toward science and technology and their applications. This relationship is in line with recent studies (Rodríguez-Entrena and Salazar-Ordóñez, 2013; Priest, 2000; Saher et al., 2006) where behavioral intentions towards innovative-product acceptance displayed some differences between the scientific–technical and social–humanistic literacy fields. A direct relationship exists between the consumer literacy fields and behavioral intentions, since science and technology students tend to be more positive about the application of technology to food.
The sustainability of food consumption is confirmed to have an impact on FTNS (+0.486). More specifically, the more sustainable the food consumption practices are, the higher the level of neophobia is for technologies in food; naturalness is seen as being in contrast to technology and innovation. This result is in line with recent literature about the consumer

preference and demand for natural attributes in food, which are perceived as unaffected by human technological advances and thus not interfering with Mother Nature (Lusk et al., 2014).
Concerning the familiarity with Shelf Life Extension technology, the models revealed that more neophobic people are those who show a low level of familiarity towards this technology (-1.894). The general skepticism towards food technology innovation is also confirmed towards the specific technology of Shelf Life Extension. Slovic's (1987) work reveals that unknown risks cause great worries. To explain this phenomenon, he suggests the familiarity hypothesis. It states that a lack of familiarity with a technology may be an underlying cause for lay people's reluctance to accept the use of new food technologies. The familiarity hypothesis is closely related to the knowledge-deficit hypothesis, which states that a lack of knowledge leads to technology rejection.

HERE TAB. 4 OLS AND LOGIT RESULTS

Models 2 to 6 noted the evaluation of consumer acceptance of specific technologies of Shelf Life Extension, expressed as a willingness to try them. Even if the same set of independent variables had been employed, it must be said that, in these models, the dependent variables measure a degree of acceptance (expressed as willing to try) rather than a level rejection, as expressed by the Food Technology Neophobia. Nevertheless, regardless of the inverted signs of the relationship, models 2-6 tend to confirm the type of relationships occurring among the dependent and independent variables of model 1. More specifically, the positive role played by food knowledge as well as by previous familiarity with this type of technology in shaping technology acceptance is confirmed. Also, education showed a direct link with a willingness to try different Shelf Life Extension technologies, as well as for the role of sustainable food consumption; the higher the attention to the environmental sustainability of food consumption, the lower the willingness to try products with Shelf Life Extension. As the main scope of these technologies is to increase the overall sustainability of food products by reducing food loss and chain fails, the mismatch evidenced by the rejection of Shelf Life Extension technology by eco-friendly individuals outlines that the innovation technology in food products is perceived by consumers as risky *per se*, regardless of the specific technology. In a nutshell, individuals characterized by high sustainability concerns fail to recognize, in science and technology, a possible contribution for a more sustainable world. The models show that the relationships within the variables under consideration are stable and moderately independent from the type of product in the object. The last model refers to a more theoretic acceptance of Shelf Life Extension technology. Unlike the previous models, the education variable is not significant, suggesting that the scientific/literacy field of study is less able to influence a theoretical technology acceptance than a concrete one, which is represented by the willingness to try real Shelf Life extended products, as in models 2-6.

4.3 Case studies

Table 5 shows the results of the paired t-test comparisons that were used to determine whether the willingness to try specific food products (mozzarella, poultry meat, sea-bream, fresh-cut salad, white bread) is influenced by Shelf Life Extension time. The sample has been split by familiarity, as this variable was shown to have an effect on Shelf Life Extension's willingness to try in the OLS regressions. The results revealed different degrees of acceptance for the specific case studies analyzed. In particular, the food products with lower Shelf Life Extension (mozzarella 2 days, poultry meat 2 days, sea-bream 2 days, fresh-cut salad 3 days, white bread 10 days) showed a higher mean value, and this difference between the two alternatives is always statistically significant. This implies that the acceptance of Shelf Life Extension technologies is affected by the extent to which shelf life is prolonged; the longer the time period, the 'less natural' the product is probably perceived.

HERE TAB. 5 PAIRED T-TEST

Among the different food products analyzed, the highest level of acceptance is for fresh-cut salad, probably due to the high consumer familiarity with this type of product, which is characterized by strong convenience gains. The impact of prior familiarity with nanotechnology on the acceptance in food applications was already noted by Binderstein et al. (2013). On the other side, the lowest level of acceptance is for seam-bream, since freshness in fish products is normally perceived as a prioritized factor, influencing purchasing behaviors.

4.4 Cluster Analysis

Table 6 displays the cluster analysis results that were used to determine the segments of individuals who present different food technology acceptance levels. A four-cluster solution grouped the participants based on their food technology neophobia, familiarity with Shelf Life extended products and the type of university curricula.

HERE TAB. 6 CLUSTER ANALYSIS

Cluster 1, called the *Confident Scientist* group, was the least likely to be technology neophobic (mean FTNS=34). They are characterized as being more receptive to extended Shelf Life products as well as being applied science students, and they have a relatively higher value of Food Knowledge and a higher previous familiarity with Shelf Life Extension. They present the highest level of acceptance for extended Shelf Life product case-studies. Not surprisingly, they are also the group that revealed the lowest degree of sustainable food consumption.
Cluster 2, called the *Cautious Scientists* group, has a positive attitude towards the application of technologies in food, but they have no familiarity with the specific case of Shelf Life Extension. Compared to Cluster 1, they are characterized by a lower level of food knowledge and a greater sustainability of food consumption.
Cluster 3, named the *Convinced Humanists*, can be distinguished by Cluster 1 and 2 mainly because of the type of curricula, which is Social Science in this case. Moreover, this cluster of respondents is defined as more food neophobic and more involved in sustainability issues. Nevertheless, they are familiar with Shelf Life Extension and willing to try this technology.
Cluster 4, named the *Skeptical Humanist*, was the most likely to refuse food technologies, having the highest level of neophobia, no familiarity with Shelf Life Extension technology, and no willingness to try Shelf Life extended food products. As expected, the highest food technology neophobia is coupled with a greater degree of sustainability of food consumption and low food knowledge. Cluster analysis identified this market segment as those who most reject the use of this technology in food products.

5. Conclusions

This study investigated consumer acceptance of new technologies in food by focusing on the specific case studies of Shelf Life Extension. The results evidenced that higher levels of food knowledge led to an increase in acceptance whereas, in contrast, a greater interest in sustainability led to technology rejection. In this context, the discussion requires us to consider the effect of these two variables interactively, in addition to their individual contributions.
The knowledge-acceptance relationship is still an important concern in communicating with citizens in a more efficient way. If knowledge represents one of the main barriers to consumer acceptance, in this direction, policies such as

information campaigns or educational programs could be recommended to make the consumers more knowledgeable and informed about food choices.

At the same time, the data reveal that, in this specific study, an increased knowledge would not be sufficient in driving consumer acceptance toward food innovation. In other words, if we consider people with a higher level of sustainability of food consumption as more concerned and knowledgeable about their food choices, this awareness is not adequate in driving the acceptance for food innovation. This raises some cues of reflection and suggests the presence of a sustainability paradox. Indeed, the main purpose for the development of Shelf Life Extension technologies is the achievement of a more sustainable food-chain, by improving the efficiency of logistics operations and reducing food waste. Nevertheless,

the consumers who are more environmentally and sustainability concerned are still those who most severely refuse such technologies. The presence of this paradox first suggests that, in the food domain, the risk perception related to the use of technologies is able to overcome environmentally driven benefit perceptions. Second, the consumer perception of sustainability issues in food is strongly associated with the idea of 'ancient naturalness'; purchasing food products is sustainable only when they are local, organic, and traditional whereas innovation and sustainability simply cannot match.

In other words, although the experts are aware that the achievement of sustainability goals can only be addressed through a combination of 'back to the past' and 'towards the future' strategies, lay people have probably not been sufficiently informed on this issue to date. In conclusion, the best policy option would rely upon interventions aimed at communicating this innovative, more inclusive approach to sustainability. The main recommendation for the food industry would be to communicate Shelf Life extended products by underlying their convenience and environmental-friendly attributes without necessarily mentioning the technology behind them. This communication strategy could also help in preventing risk overestimation by unfamiliar, low-knowledge consumers, the group that was more technology adverse. This study has some limitations. The nature of the face-to-face survey raises the issues of social desirability bias and under/over estimation of responses due to stated preferences, which can partially affect the results of the present study. The second issue is related to the sample, Millennial Students, which represents a very specific population and, consequently, does not allow us to generalize the results. Moreover, the analysis refers to the case of Italy, and further research is needed to verify the outcomes in other countries with different characteristics.

Tab. 1 Descriptive statistics

Variable name	Scale	Description	Min	Max	Mean	Range	Freq
Education_curricula	dummy	*University degree*	0	1			
social							537
applied science							490
Age	continuous		21	29	24.21		
Gender	dummy		1	0			
male							381
female							646
FTNS	continuous	*Food Technology Neophobia Scale*	19	91	49.46	13-91	
FKN	continuous	*Food Knowledge*	2	29	20.29	0-30	
SFC	continuous	*Index of Sustainability of Food Consumption*	0	12	7.28	0-12	
Familiarity SLE	dummy	*Have you ever heard about Shelf Life Extension technology?*	0	1			
no							509
yes							518
Willing try_SLE	dummy	*Should you be willing to try SLE food products?*	0	1			
no							456
yes							571
Ebs_people impact		*15 years from now, what impact do you think people's actions and behavior will have on availability and quality of food?*	0	3			
do not Know	dummy		0	1			227
negative	dummy		0	1			565
neutral	dummy		0	1			27
positive impact	dummy		0	1			208
Ebs_sci&tech impact		*15 years from now, what impact do you think science and technological innovation will have on availability and quality of food?*	0	3			
do not Know	dummy		0	1			221
negative	dummy		0	1			85
neutral	dummy		0	1			17
positive impact	dummy		0	1			704
Mozzarella_Low SLE	continuous	*Should you be willing to try a mozzarella cheese whose shelf life has been extended of 2days?*	0	7	2.33		
Mozzarella_High SLE	continuous	*Should you be willing to try a mozzarella cheese whose shelf life has been extended of 5 days?*	0	7	1.62		
Poultry_Low SLE	continuous	*Should you be willing to try poultry meat whose shelf life has been extended of 2days?*	0	7	2.45		
Poultry_High SLE	continuous	*Should you be willing to try poultry meat whose shelf life has been extended of 5 days?*	0	7	1.71		
Sea bream_Low SLE	continuous	*Should you be willing to try a sea bream whose shelf life has been extended of 2days?*	0	7	1.83		
Sea bream_High SLE	continuous	*Should you be willing to try a sea bream whose shelf life has been extended of 4 days?*	0	7	1.31		
Fresh cut salad_Low SLE	continuous	*Should you be willing to try a fresh cut salad whose shelf life has been extended of 3 days?*	0	7	2.73		
Fresh cut salad_High SL	continuous	*Should you be willing to try a fresh cut salad whose shelf life has been extended of 9 days?*	0	7	1.66		
White bread_Low SLE	continuous	*Should you be willing to try a white bread whose shelf life has been extended of 10 days?*	0	7	2.07		
White bread_High SLE	continuous	*Should you be willing to try a white bread whose shelf life has been extended of 20 days?*	0	7	1.45		

Tab. 2 Food Technology Neophobia Scale

Factor	Description	Item	Loading	Mean	Std. Dev.
1	New food technologies are unnecessary	There is no sense trying out high-tech food products because the ones I eat are already good enough	0.709	2.270	1.556
		New food technologies are something I am uncertain about	0.588	3.981	1.868
		New foods are not healthier than traditional foods	0.729	3.422	1.811
		The benefits of new food technologies are often grossly overstated	0.608	3.907	1.668
		There are plenty of tasty foods around, so we do not need to use new food technologies to produce more	0.724	2.656	1.751
		New food technologies decrease the natural quality of food	0.646	3.552	1.842
2	Healthy choice	New food technologies are unlikely to have long-term negative health effects ®	0.673	4.481	1.549
		New food technologies give people more control over their food choices ®	0.818	3.870	1.605
		New products using new food technologies can help people have a balanced diet ®	0.765	3.712	1.579
3	Perception of risks	New food technologies may have long-term negative environmental effects	0.738	3.844	1.613
		It can be risky to switch to new food technologies too quickly	0.779	4.453	1.799
		Society should not depend heavily on technotechno logies to solve its food problems	0.601	3.633	1.984
4	Information/media	The media usually provide a balanced, unbiased view of new food technologies ®	0.914	5.681	1.479

Tab.3 Sustainability of Food Consumption

Items	*I am doing this already (%)*	*I would like to do this (%)*	*I am not doing this and I am not willing to (%)*
Buy regional (local) food	71.08	18.70	10.22
Avoid products with excessive packaging	44.40	28.43	27.17
Buy organic food	49.17	21.32	29.50
Eat only seasonal fruit and vegetables	46.93	39.05	14.02
Eat meat at most twice a week or little at a time	49.37	20.55	30.09
Avoid food products that were imported by airplane	23.95	30.19	45.86

Tab. 4 OLS and Logit results

	FTNS	Mozzarella Low SLE	Poultry Low SLE	Fresh cut salad Low SLE	White bread Low SLE	Sea-bream Low SLE		Willing to try SLE product
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*		*Model 7*
Food Knowledge	-0.321 ***	0.049 **	0.045 **	0.042 *	0.065 ***	0.034 *		0.055 ***
	(0.089)	*(0.017)*	*(0.017)*	*(0.018)*	*(0.018)*	*(0.016)*		*(0.017)*
Education_Curricula *(Applied science=1)*	-3.115 ***	0.434 ***	0.410 **	0.196	0.457 **	0.494 ***		0.082
	(0.731)	*(0.139)*	*(0.139)*	*(0.149)*	*(0.144)*	*(0.132)*		*(0.138)*
Sustainability food consumption	0.486 ***	-0.059 **	-0.105 ***	-0.120 ***	-0.077 **	-0.113 ***		-0.112 ***
	(0.346)	*(0.025)*	*(0.025)*	*(0.027)*	*(0.026)*	*(0.024)*		*(0.026)*
Familiarity SLE *(Yes=1)*	-1.894 **	0.434 ***	0.335 *	0.404 **	0.205	0.362 **		0.499 ***
	(0.694)	*(0.133)*	*(0.132)*	*(0.142)*	*(0.136)*	*(0.125)*		*(0.1312)*
Cons	54.846 ***	1.341 ***	1.926 ***	2.460 ***	0.998 **	1.533 ***		-0.366
	(1.860)	*(0.353)*	*(0.353)*	*(0.379)*	*(0.366)*	*(0.335)*		*(0.352)*
Obs	1027	1027	1027	1027	1027	1027		1027
R2	0.164	0.145	0.144	0.135	0.144	0.154	R2 Cox	0.144
R2 adj	0.161	0.141	0.141	0.131	0.140	0.150	R2 Nagelke	0.159
F	17.546 ***	11.967 ***	11.873 ***	9.156 ***	11.798 ***	14.461 ***	Wald	12.82 ***

Tab. 5 paired t-test

		FAMILIAR				UNFAMILIAR			
Product	**SLE**	**Mean**	**SD**	**Corr.**	**Sig.**	**Mean**	**SD**	**Corr.**	**Sig.**
Mozzarella	2 days	2.59	2.19	0.72	***	2.06	1.99	0.79	***
	5 days	1.79	1.99			1.44	1.74		
Poultry meat	2 days	2.65	2.16	0.734	***	2.24	2.04	0.74	***
	5 days	1.86	2.00			1.56	1.8		
Sea bream	2 days	2.04	2.11	0.83	***	1.62	1.89	0.77	***
	4 days	1.45	1.87			1.16	1.59		
Fresh cut salad	3 days	2.95	2.3	0.68	***	2.51	2.19	0.72	***
	9 days	1.78	2.11			1.54	1.94		
White bread	10 days	2.23	2.26	0.81	***	1.91	2.1	0.79	***
	20 days	1.53	2.03			1.36	1.87		

Tab.6 Cluster Analysis

	Cluster 1 (n=183)	Cluster 2 (n=355)	Cluster 3 (n=372)	Cluster 4 (n=117)
Food technology Neophobia Scale	34	44.7	55.2	69.8
Willing to try SLE product	Yes	Yes	Yes	No
Food Knowledge	21.8	20.6	19.5	19.5
Education_Curricola	Applied	Applied	Social	Social
Sustainability of Food Consumption	6.8	7.2	7.5	7.5
Familiarity SLE	Yes	No	Yes	No
Mozzarella 2gg	3	2	2	1
Poultry_LowSLE	4	2	2	2
Fresh Cut Salad_LowSLE	4	3	3	2
White Bread_LowSLE	3	2	2	1
Sea Bream _LowSLE	3	2	2	1