Factors determining neophobia and neophilia with regard to new technologies applied to the food sector: A systematic review

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ABSTRACT

This systematic review was performed starting from the understanding of the complexity that characterizes the human relationship to food, combining different dimensions, ranging from those aspects going from the biological (nutritional function) to the cultural (symbolic function), as well as the ones linking the individual to the community, the psychological to the social. Addressing this multi-dimensional character is at the base of sound research paths aiming at assessing the determinants of consumers’ choices and behaviors. This systematic review analyses and synthetizes the main results of recent studies dealing with food neophobia and neophilia with regard to new technologies applied to the food sector, both in the context of developed countries and in developing ones. In particular, main factors leading to caution and aversion for food technologies were identified and discussed, as well as different approaches to measure consumers’ resistance to the mentioned technologies and to predict consumers’ behavior. Scopus and Web of Science engines were used to search the existing literature and to identify the relevant studies to include, conducted in different countries and by means of different methodological approaches. These studies investigated the mentioned consumers’ choices and behaviors, that are influenced by many interacting factors; the adoption of a relevant conceptual framework allows the distinction between distal (or primary) determinants, and proximal (or secondary) ones. Communication and attitudes or psychometric models constitute the base of the cited framework, and the link between the two determinants categories. In particular, an effective tool capable of enhancing the understanding of the neophobia–neophilia forces that determine food choices is the Food Technology Neophobia Scale (FTNS), with its fourcomponents constituting the base of a sound analysis of the influence on the mentioned choices of each single neophobia–neophilia force (risk perception and novelty seeking, media influence, own health and environmental concerns) as well as a device to turn the four components into a single, comprehensive framework. Finally, the case of consumer acceptance of the eating of insects is discussed as an emerging trend in food science.

Introduction

As the benefits brought to the consumer exceed market failures, new food technologies are increasingly introduced, especially in developing regions (Rollin et al., 2011). Consumers are aware of the risks associated with food applications (Frewer et al., 2011; Rollin et al., 2011; Siegrist, 2008), in fact, massive food researches are carried out concerning consumers’ fear of novel food, defined as “food neophobia” (Caracciolo et al., 2011; Chen et al., 2013; Coppola et al., 2014; Cox and Evans, 2008; Frewer et al., 2011; Matin et al., 2012; Pliner and Hobden, 1992; Siegrist, 2008; Verneau et al., 2014). Despite being a personality trait (Pliner and Salvy, 2006), food neophobia has also been studied as a form of behavior (Pliner and Salvy, 2006; Ritchey et al., 2003). New food technologies market success depends on consumers’ behavioral responses (Chen et al., 2013), as a consequence, negative and suspicious feelings towards food technologies may lead to product failures. Thus, as a support to marketing research, it is essential to focus on population segments that are food technology neophobic as well as early adopters of such innovative technologies (Evans et al., 2010).

Food neophobia, as well as involving the unwillingness to try new foods, also implies consumers’ reluctance for new technologies in processing and producing food, known as food technology neophobia...
(e.g., Bäckström et al., 2004; Choe and Cho, 2011; Cox and Evans, 2008; Grunert et al., 2003; Lähteenmäki et al., 2002). Generally speaking, there are three key reasons for rejection of food by humans: (a) aversion to sensory characteristics, (b) danger, a fear of negative consequences of eating a food or (c) disgust, arising from the idea of nature or origin of food (Vidigal et al., 2015).

Moreover, consumers’ hesitation to try foods produced by new food technologies hinges on some main factors such as: functional barriers connected to simple use, benefits and risks feelings, knowledge and attitudes, socio-demographic and lifestyle factors and psychological barriers (Chen et al., 2013; Frewer et al., 2013; Ronteltap et al., 2007); conversely, neophobes people perceive unusual foods in a positive light and embrace situations involving new foods (Fenko et al., 2015a, 2015b). Assessment of food neophobia as a personality trait may be performed with measuring scales known as Food Neophobia Scale – FNS (Pliner and Hobden, 1992). Neophobia can also be studied as a state and thus be measured with the use of task-based experiments involving several tests evaluating, inter alia, willingness to try unfamiliar food products or food preferences (Pliner and Loewen, 2002). Different works have shown that the Food Neophobia Scale (FNS) developed by Pliner and Hobden (1992), measuring willingness to taste novel foods, predicts responses to novel or unknown food, including ethnic food (Tuorila et al., 2001; Ritchey et al., 2003; Urala and Lähteenmäki, 2007). As above stated, with reference to food and food technology neophobia, the Food Neophobia Scale (FNS) (Pliner and Hobden, 1992) can provide a standardized measurement to evaluate the connection between appetite and food aversion (Choe and Cho, 2011; Olabi et al., 2009).

The FNS is linked to general neophobia, trait anxiety, sensation seeking (Pliner and Hobden, 1992) and it is also believed that it provides accurate responses to novel or unfamiliar food (Lähteenmäki et al., 2002; Ritchey et al., 2003). If on the one hand, the FNS is a suitable tool to assess consumers’ reactions towards ethnic or other culture food (Pliner and Hobden, 1992), on the other hand, it does not properly work to examine the acceptance of foods produced by novel technologies (Cox and Evans, 2008; Frewer et al., 2011; Siegrist, 2008).

As a matter of fact, food neophobia is also linked to the acceptance of new technologies used in food production and processing (Ronteltap et al., 2007; Siegrist et al., 2007); however, numerous studies showed that the Food Neophobia Scale is not reliable for assessing receptivity to foods produced by new technologies (Bäckström et al., 2004; Cox and Evans, 2008; Siegrist, 2008). Thus, the Food Technology Neophobia Scale (FTNS) was developed (Cox and Evans, 2008). This validated scale could be used to identify segments of consumers with greater or lesser neophobia (Evans et al., 2010). The Food Technology Neophobia Scale (FTNS) (Cox and Evans, 2008; Evans et al., 2010) is thought to be a more suitable tool than the Food Neophobia Scale (FNS) (Pliner and Hobden, 1992) to draw consumer perceptions of food technologies. Its development is accurately described in this review.

Consumers might taste new foods independently from their neophobia for different reasons such as: hedonism, ease of preparation of the food, its nutritional component, the positive influence on the quality of their life and for a healthy diet (Barrena and Sánchez, 2013). Academic studies underline that the suspicious for novel foods is connected to neophobia and report lower reluctance towards new products among consumers that are less neophobic (Pliner and Hobden, 1992; Barrena and Sánchez, 2013).

Scientific and technological innovations have contributed to the enhancement of man’s quality of life; many of these technology-based innovations have been incorporated into daily life while others have met with some resistance (Ronteltap et al., 2007; Cardello, 2003a, 2003b). This has stimulated research to understand consumer acceptance of technology-based innovations; such research is most prominent in the areas of information technology, high-technology products and service delivery (Ronteltap et al., 2007). Within the food area some relatively recent technology-based innovations have been adopted easily and others essentially rejected by consumers (Cardello, 2003a, 2003b), such as genetically modified foods (GMFs) in Europe and food irradiation.

Carayannis et al. (2003) distinguish between technology and innovation. Technology is the whole complex of knowledge, skills and equipment necessary to produce a product or service. These new products or services are considered to be innovations.

Lam and Parasuraman (2005) operationalise technology acceptance as the initial acquisition of a technology-based product or subscription to a technology-based service. Much of the insight in technology acceptance is derived from consumer acceptance of its innovations.

One of the reasons for such interest in new food technologies is the anticipated range of benefits they can bring to the consumer and the food sector. The reported advantages include safer, healthier more nutritious foods using less energy, water and chemicals and producing less waste. However, the toxicological nature of hazard, likelihood of exposure and risk to consumers from some new food technologies are largely unknown (Chaudhry et al., 2008).

In the area of food and nutrition, various technological applications have emerged, and will be shortly described in the following paragraph: related to prolonging the shelf life of foods and enhancing their safety, e.g., pasteurisation, and novel food packaging. In recent years, many of the new food technologies and food innovations have been targeted at the promotion of good health. Fortification and restoration of foods were used as methods to add nutrients to food products; functional foods and nutraceuticals constitute a range of novel foods designed to deliver benefits beyond nutritional value to the person consuming them (Frewer et al., 2003), and the so called nutraceuticals provide medical or health benefits by maintaining and modifying bodily functions (Hardy, 2000).

As a matter of fact, past episodes of food safety incidents have led to low public confidence in food safety systems (Curtis et al., 2004; Frewer and Saller, 2002; Verbeke et al., 1999); moreover, several new food technologies faced unsupportive attitudes when they first appeared, such as canned food, pasteurised milk, artificial insemination of farm animals, microwave cooking (IPT, 2000). A recent review commissioned by the Food Standards Agency (FSA) in the UK (Pull, Wilkins et al., 2009) confirmed that nowadays European consumers still tend to associate more negative than positive attributes to agro-biotechnology in general, such as wariness, unease and uncertainty.

Consumer acceptance is driven by risk perception and by the perception of the potential benefits (Ronteltap et al., 2007); a lack of perceived benefits leads the majority of people to question the need for, and usefulness of, novel food technologies, and may even accentuate perceived risks and moral concerns (Gaskell, 2000).

Consumer acceptance of innovations has been approached from various disciplines and theoretical perspectives; a rough distinction can be made between research at the (macro-) level of society, for example, by sociologists and economists, and at the (micro-) level of individual consumer behaviors, for example, by psychologists and researchers of perceived risk. Starting from the conceptual framework developed by Ronteltap et al. (2007), in this review the different factors related to consumers’ acceptance of food technologies will be analysed; the aim is twofold: on one hand, the mentioned comprehensive conceptual framework will be broadened through the investigation of the most recent literature regarding neophobia/neophilia forces; on the other hand, in addition to past reviews in the mentioned field, the analysis of the primary and secondary determinants is integrated with an in depth illustration of the different aspects related to measurement tools such as the Food Technology Neophobia Scale (FTNS), as well as with the identification of the issues related to the emerging sector of entomophagy. The case of consumers’ acceptance of the eating of insects is analysed in relation to its being significant to the main theme of this review, and to the investigation of neophobia/neophilia forces.

**Literature searching criteria**

The search strategy was designed to investigate published scientific articles and to select the relevant ones, all following a specific protocol...
that embeds replicable and transparent procedures specified in advance (Littell et al., 2008). As a matter of fact, objectivity and transparency are fundamental principles for a sound systematic review and allow to minimize bias typical of narrative summaries of past research.

The initial stage consisted of a search of Scopus (2000–2016) and Web of Science (2000–2016), by means of the identification of relevant keywords contained in the title, abstract and subject descriptors. In particular, the Boolean operator “AND” was used to obtain all possible alternative combinations of selected keywords. Keywords: a) food neophobia, food neophilia; b) consumers behavior, attitude, risk acceptance, risk perception; c) food technology, food processing, innovation, agri-food industry.

Articles identified on the basis of information contained in the title (n. 151): Web of Science (n. 74), Scopus (n. 77)

Duplicated articles (n. 73)

Articles retrieved for detailed evaluation (n. 78)

- Articles excluded on the basis of information contained in the abstract (n. 15)
- Articles not focused on review topic

Articles identified on the basis of information contained in the abstract (n. 63)

Articles excluded on the basis of information contained in the full text (n. 10)
- Articles not focused on food technology (n. 4); Articles not focused on specific case studies (n. 6)

Articles identified on the basis of information contained in the full text (n. 53)

These keywords were identified to include those articles that take in consideration studies pertaining the analysis of neophobia/neophilia forces rather than mere consumers’ behavior analysis.

Articles were selected firstly through their title, at a second stage by means of the abstract content and, thirdly, through examination of full text, all in order to perform an extensive and effective search of the literature. Reference lists and bibliographies of the selected articles were also searched, and full copies of articles considered consistent with the previously outlined criteria were searched for data collection, synthesis and analysis.

The described search was carried out in September 2016; in order to focus on the most recent studies on the topic of interest, the search was limited to the post 2006 period which was considered reasonable to keep out the most outdated trends. Only past research with a high degree of visibility within the scientific community was included; to this extent, only those papers written in English language and published in scientific journals were selected. Both studies from developed and developing countries were considered, due to the relative newness of the topic of interest and to the need to investigate its recent applications in different contexts; in total, n.151 articles were selected on the basis of the above mentioned keywords, n.74 identified through Web of Science and n.77 via Scopus. In light of the exclusion of duplicated articles extracted from these two databases (n.73), the final list of articles used for detailed evaluation was composed of n.78 studies; after having further reviewed the remaining articles by means of the above mentioned procedure (title, abstract and full content), n.15 articles were excluded on the basis of information contained in the abstract, as they were not specifically focused on the topic of interest for this review. A last evaluation of the full text of the remaining n.63 studies brought to the exclusion of n.10 articles, not focused on food technology (n.4) or not focused on specific case studies (n.6); as a consequence, the final sample for an in depth study contained n.53 articles. (Table 1)

Flow Chart Articles Submission

Technologies overview

As a result of the literature review conducted and on the basis of the different types of existing food technologies (Siegrist, 2008), with reference to examined past research, an overview of the main aspects of these same technologies is of relevant interest (Rollin et al., 2011). Further analysis will be conducted together with the review of factors influencing consumers’ attitudes and behavior.

Nanotechnologies

Nanotechnologies remain problematic in terms of their definition (Schnettler et al., 2016a, 2016b). However, in general, studies agree on considering materials including “structures of less the 100 nm for at least one dimension (including) free nanoparticles or nanomaterials” (Dekkers et al., 2006). The opinion of both industry stakeholders and the general public reveals stakeholders to have high levels of awareness with lower levels of actual knowledge and reasonably high levels of concerns in terms of risk. NGOs recommended public consultation on risk/benefits and case-by-case evaluation and labelling. Consumers demonstrate low but increasing awareness; by 2005, 48% considered it would have positive effects on their life in the next 20 years (Eurobarometer, 2005). Nanotechnologies are generally
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<th>Country</th>
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<th>Type of products analysed</th>
<th>Technology</th>
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<tbody>
<tr>
<td>1</td>
<td>Evans et al. (2010)</td>
<td>Reliability of the FTNS</td>
<td>Australia</td>
<td>Two stage-study, questionnaire + food tasting; period not specified</td>
<td>131</td>
<td>All types of consumers</td>
<td>18–67</td>
<td>FTNS; ANOVA</td>
<td>7 Food products labeled as traditional and as technology</td>
<td>Pasteurisation, bioactive, fortification, selective breeding, triploidy, genetic modification and nanotechnology Not specified</td>
</tr>
<tr>
<td>2</td>
<td>Schnettler et al. (2016, 2016b)</td>
<td>Psychometric properties of the FTNS</td>
<td>Chile</td>
<td>Survey through questionnaire; July and August 2013</td>
<td>400</td>
<td>200 supermarket shoppers + 200 university students</td>
<td>Not specified</td>
<td>FTNS; Correlation analysis; CFA</td>
<td>Not specified</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Verneau et al. (2014)</td>
<td>Consumers' preferences for some familiar highly processed foods</td>
<td>Italy</td>
<td>Questionnaire face-to-face; October 2011</td>
<td>575</td>
<td>Supermarket shoppers</td>
<td>17–84</td>
<td>FTNS; Probit regressions</td>
<td>Fat-reduced; functional (enriched drinks and yogurt); ready-to-eat frozen food</td>
<td>Functional Food</td>
</tr>
<tr>
<td>4</td>
<td>Kim et al. (2014)</td>
<td>Theory of Planned Behavior and GM food</td>
<td>South Korea</td>
<td>Survey through questionnaire; October 2013</td>
<td>440</td>
<td>All types of consumers</td>
<td>Not specified</td>
<td>Structural Equation modeling</td>
<td>GM Foods</td>
<td>GM</td>
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<td>5</td>
<td>Vidigal et al. (2015)</td>
<td>Consumers' behavior in relation to different food technologies</td>
<td>Brazil</td>
<td>Survey through questionnaire; period not specified</td>
<td>389</td>
<td>Habitual or potential consumers of yogurt</td>
<td>Not specified</td>
<td>FTNS; ANOVA</td>
<td>Yogurt labeled as traditional and as technology</td>
<td>Biocactive, nanotechnology</td>
</tr>
<tr>
<td>6</td>
<td>Chen et al. (2013)</td>
<td>Consumers' perceptions and WTP for vacuum packaging of fresh beef</td>
<td>Canada</td>
<td>Three stage-study, experimental rounds with repeated choice decisions; period not specified</td>
<td>108</td>
<td>Primary grocery shoppers in household</td>
<td>&gt; 18</td>
<td>Multinomial logit and mixed logit models</td>
<td>Vacuum-packaged beef steaks</td>
<td>Not specified</td>
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<tr>
<td>7</td>
<td>Hartmann et al. (2015)</td>
<td>Factors influencing willingness to eat insects</td>
<td>Germany, China</td>
<td>Survey through questionnaire; October 2014</td>
<td>502 Germany</td>
<td>All types of consumers</td>
<td>20–69</td>
<td>Two-way mixed ANOVA</td>
<td>Insects</td>
<td>Nanotechnology applications to foods and to the packaging of foods</td>
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<td>8</td>
<td>Matin et al. (2012)</td>
<td>Consumers' attitudes towards applications of nanotechnology in the food industry</td>
<td>Canada</td>
<td>Survey through questionnaire; January–February 2010</td>
<td>837</td>
<td>All types of consumers</td>
<td>&gt; 15</td>
<td>Multinomial regression analysis</td>
<td>Nanotechnology applications to foods and to the packaging of foods</td>
<td>Nanotechnology</td>
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<td>9</td>
<td>Caparros Megido et al. (2013)</td>
<td>Perception of entomophagy and purchase intentions</td>
<td>Belgium</td>
<td>Survey through questionnaire + Hedonic tests; period not specified</td>
<td>189</td>
<td>All types of consumers</td>
<td>Not specified</td>
<td>ANOVA with linear model</td>
<td>Insects</td>
<td>Not specified</td>
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<tr>
<td>10</td>
<td>De Steur et al. (2015)</td>
<td>Application of the FTNS</td>
<td>Uganda</td>
<td>Questionnaire face-to-face; April-May 2013</td>
<td>220</td>
<td>Grocery shoppers in household</td>
<td>Not specified</td>
<td>FTNS; EFA (Exploratory Factor Analysis)</td>
<td>Mānuka (cooking banana) fresh VS processed</td>
<td>Not specified</td>
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<td>12</td>
<td>Lease et al. (2014)</td>
<td>Hedonic and emotional responses related to food technologies</td>
<td>Australia</td>
<td>Direct tasting sessions; period not specified</td>
<td>101</td>
<td>Grocery shoppers in household + regular consumers of beef products</td>
<td>25–65</td>
<td>ANOVA; Correlation analysis; FTNS</td>
<td>Meat products obtained using recycled water</td>
<td>Not specified</td>
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<td>13</td>
<td>Coppola et al. (2014)</td>
<td>Consumers' attitudes towards food technologies and purchasing intentions</td>
<td>Italy</td>
<td>Field survey through 3-parts questionnaire; Summer 2010</td>
<td>355</td>
<td>Primary grocery shoppers in household</td>
<td>Not specified</td>
<td>Multivariate analysis; FTNS; EFA (Exploratory Factor Analysis); Probit</td>
<td>6 food categories: functional, low-fat, frozen ready-to-eat, organic, typical; short-chain</td>
<td>Functional Food</td>
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<td>14</td>
<td>Labrecque et al. (2006)</td>
<td>Cross-cultural variance of functional food acceptance</td>
<td>France, USA and French Canada</td>
<td>Self-administered questionnaire; 2004</td>
<td>163 France, 155 USA; 227 French Canada</td>
<td>College/ University students</td>
<td>18–25</td>
<td>Linear regression analysis; Factor analysis (Oblimin rotation)</td>
<td>3 functional products: eggs with Omega 3; Milk with calcium; Orange juice with Calcium</td>
<td>Functional Food</td>
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<td>15</td>
<td>Jezewska-Zychowicz et al. (2015)</td>
<td>Relationships between willingness to eat cereal products fortified with fibre and attitudes towards food technologies</td>
<td>Poland</td>
<td>Survey through questionnaire; October and November 2013</td>
<td>1000</td>
<td>Primary grocery shoppers in household</td>
<td>18–83</td>
<td>Pearson correlation coefficients; FTNS</td>
<td>Cereal products fortified with fibre</td>
<td>Not specified</td>
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<td>16</td>
<td>Den Uijl et al. (2014)</td>
<td>Emotions associated with mealtimes and snack times in older persons</td>
<td>Netherlands</td>
<td>Survey through three questionnaires; period not specified</td>
<td>392</td>
<td>Grocery shoppers</td>
<td>55–85</td>
<td>Cluster analysis</td>
<td>Not specified</td>
<td>Not specified</td>
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<td>17</td>
<td>Cox et al. (2008)</td>
<td>Development of the FTNS</td>
<td>Australia</td>
<td>Three stage-study through questionnaires; period not specified</td>
<td>480 Stage 1; 459 Stage 2; 369 Stage 3</td>
<td>University students Stage 1; Grocer shoppers Stage 2 and 3</td>
<td>&gt; 18</td>
<td>ANOVA; Correlation analysis; FTNS</td>
<td>Fruit juice, salads, prawns, olseeds high in omega-3, yoghurt</td>
<td>Pasteurisation, bioactive, high pressure processing, modified atmosphere packaging, triploidy and genetic modification</td>
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<td>18</td>
<td>Barrenar et al. (2015)</td>
<td>Variations in consumers' cognitive structure in relation with age ranges</td>
<td>Spain</td>
<td>Three-stage qualitative interview with laddering technique; March and April 2011</td>
<td>98</td>
<td>Grocery shoppers in household</td>
<td>18–65</td>
<td>MEC (Means-end chain); Hard laddering</td>
<td>Coffee and coffee capsules</td>
<td>Not specified</td>
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<td>19</td>
<td>Baker et al. (2016)</td>
<td>Influence of images and descriptions on consumers' perceptions and purchase intentions of edible insect food products</td>
<td>USA</td>
<td>Three Studies: Study 1 Retail setting; Study 2 Restaurant setting; Study 3 Support findings from 1 and 2. Direct test through images and descriptions; period not specified</td>
<td>221 Study 1; 200 Study 2; 201 Study 3</td>
<td>All types of consumers</td>
<td>Not specified</td>
<td>Multivariate analysis of covariance (MANCOVA); FNS; Mediation tests</td>
<td>Insects</td>
<td>Not specified</td>
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<td>20</td>
<td>Villegas et al. (2008)</td>
<td>Influence of information and attitudes on hedonic ratings and purchasing intentions</td>
<td>Spain</td>
<td>Two-stage-study, questionnaire + food tasting; period not specified</td>
<td>120</td>
<td>Habitual consumers of milk and/or vegetables beverages</td>
<td>Not specified</td>
<td>Two-way mixed ANOVA; FNS</td>
<td>3 types of vanilla milk + 3 soybean beverages</td>
<td>Not specified</td>
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<td>21</td>
<td>Verheke (2015)</td>
<td>Readiness to adopt insects as meat substitutes</td>
<td>Belgium</td>
<td>Survey through questionnaire; December 2013</td>
<td>368</td>
<td>Habitual meat consumers</td>
<td>18–79</td>
<td>FTNS; FNS; CONVOR Scale</td>
<td>Insects</td>
<td>Not specified</td>
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<td>22</td>
<td>Urala et al. (2007)</td>
<td>Attitudes affecting willingness to adopt functional foods</td>
<td>Finland</td>
<td>Two-stage-survey through questionnaire; Winter 2002 and Spring 2004</td>
<td>1156 Winter 2002; 1113 Spring 2004</td>
<td>Grocer shoppers in household</td>
<td>15–78</td>
<td>Factor analysis; Correlation analysis; Psychometric scales</td>
<td>8 Functional food products + 2 Reference products</td>
<td>Functional Food</td>
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<td>23</td>
<td>Verheke et al. (2015)</td>
<td>Determinants affecting consumer acceptance of cultured meat</td>
<td>Belgium</td>
<td>Web-based survey through questionnaire; April 2013</td>
<td>180</td>
<td>Mainly Student population &lt; 30 (75%)</td>
<td>EFA (Exploratory Factor Analysis)</td>
<td>Cultured meat</td>
<td>Not specified</td>
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<td>Mustonen et al. (2007)</td>
<td>Association between initial liking of specific foods and future choices</td>
<td>Finland</td>
<td>Three stage-study, evaluation sessions with direct tasting; period not specified</td>
<td>71</td>
<td>Grocer shoppers in household + regular consumers of cheese</td>
<td>Two-way ANOVA</td>
<td>6 types of cheese</td>
<td>Not specified</td>
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<td>Schnettler et al. (2016a, 2016b)</td>
<td>Relationships between food neophobia, satisfaction with life and acceptance of</td>
<td>Chile</td>
<td>Survey through questionnaire; period not specified</td>
<td>400</td>
<td>Supermarket shoppers</td>
<td>&gt; 18</td>
<td>FNS, Psychometric scales, Cluster analysis</td>
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<td>Stratton et al. (2015)</td>
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<td>University students</td>
<td>Not specified</td>
<td>FTNS; Rounds of implicit WTP</td>
<td>Pack of two 400-gram crushed tomatoes (conventional and enriched with lycopene)</td>
<td>Functional Food</td>
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perceived as useful and morally acceptable in Europe and even more so in the US and Canada. Women and older demographics are generally less optimistic about nanotechnologies although older generations see its use in packaging as more useful. Labelling of products remains complex and while 70% of stakeholders (Landmark Europe, 2009) call for labelling of food products derived from nanotechnology, it is unclear how consumers may interpret such labelling. As to applications of nanotechnology, they represent a growing field, but the public opinion is not clear-cut; in fact, there are a few researches on its perception by consumers (Chaudhry et al., 2008; Matin et al., 2012; Siegrist et al., 2008); investments from government agencies and industry might contribute to the development of nanotechnology (Frewer et al., 2011).

GMOs

GMOs refer to “organisms in which genetic material has been modified” (WHO, 2009), “with a new or intentionally modified primary molecular structure” (Rollin et al., 2011). The EU has, since 2005, lifted its ban on GM food and now ensures traceability in GMO food products and has implemented a broad regulatory framework. Awareness of GMOs in Europe is higher than for other food technologies (80% aware - Eurobarometer, 2005). GM medicines are more generally accepted than food. GMO food is also less accepted when the food is considered as naturally healthy in origin. Geographic differences exist in Europe in terms of acceptance, with Southern Europe generally more tolerant. Consumers in the US and developing countries are also more tolerant than Europeans, partly due to greater perceived benefits/lower perceived risks. Risk perception in the EU is high; 62% of Europeans are “worried” about GM foods (Eurobarometer, 2006b). Perceived risks include the development of “super weeds”, harm to human health and the environment; perceived benefits include longer shelf life and flavour enhancement. Clear separation is made for consumers between personal and collective benefits. Women and older generations tend to be less accepting of GMOs and education and information on benefits has had mixed results and trust is also divided between different industry sectors. Consumers would like better labelling and traceability; some countries market food with “GM-free labels” while others prohibit such practice yet shoppers generally do not pay great attention to labelling when purchasing food and generally do not avoid GM-labeled products (Landmark Europe, 2009). As far as perceptions related to different countries, American consumers tend to be more positive on genetically modified food than European and Japanese costumers. (Gaskell, 2000; Lusk et al., 2003). Schnettler et al. (2013) underline that among developing countries there are positive feelings towards genetically modified foods, such as in Brazil (Da Costa et al., 2000), China (De Steur et al., 2010) and Kenya (Kimenju and De Groote, 2008), but in other developing countries, perceptions are not so positive, as is the case of Argentina (Mucci et al., 2004) and Chile (Schnettler et al., 2012).

Nutrigenomics

Nutrigenomics is a relatively new field (emerging in 2000) and concerns an understanding of how nutrition may affect the body of an individual in terms of the equilibrium of health, diet and disease and how individual genotypes may interact with nutritional processes. It is sometimes considered as “personalized” nutrition. European studies reveal respondents as generally willing to undergo genetic testing (66.6%; Stewart-Knox et al., 2009), although positive responses were more likely from those with reported health problems, results that may produce target demographics for stakeholders. Concern may be raised among consumers of the interplay between genetics and nature and the potential cost of such technology (Ronteltap et al., 2007). However, benefits may include healthier lifestyles and extended life spans assuming motivation by consumers to follow personalized nutrige-
nomic nutritional plans. The oldest age group showed the greatest willingness to undergo genetic testing.

Food irradiation

Food irradiation refers to a technique of applying beam and ray technology in order to kill bacteria, control infestation and delay ripening and sprouting in fruit and vegetables, similar to pasteurisation techniques. Varying doses may be applied in order to either reduce bacteria or create sterile foods (consumed by sufferers of AIDS or cancer) and is a technique successfully applied by a number of countries worldwide. EU legislation on food irradiation is based on favourable opinions yet the practice must not be used to conceal poor production practices or low quality. Irradiated food is thus considered as a safe and useful process on a legislative level. Food modified according to this technique must clearly carry the word “irradiated” on either the packaging or next to ingredients, along with an option symbol. Consumers demonstrate generally negative attitudes towards irradiation despite the view of the scientific community that it is a safe and effective process. Consumer resistance has hampered the development of this technology. While education on the technique has generated positive results, 1 in 3 consumers reported (He et al., 2005a; Cardello et al., 2007) that the word “irradiated” on labelling would put them off a potential purchase.

Animal cloning

While animal cloning is not banned in the EU, it is not a commercial practice and the European Parliament is aiming towards its prohibition. However, the lack of a proven safety risk on the part of the European Food Safety Agency means it is unable to justify a potential ban to the WTO. The US has upheld a voluntary ban on the sale of cloned products since 2001. Consumer acceptance and awareness of animal cloning is in line with GM technology inasmuch as in Europe there is generally high awareness and low acceptance. It is considered morally wrong with just one-third of EU citizens considering it as acceptable if it were to solve worldwide food issues (Eurobarometer, 2008; Gaskell, 2000). Scientists are seen as the most trustworthy source of information on the safety of cloning and 8 out 10 EU citizens would want appropriate labelling should cloned products appear in the shops in the future (Eurobarometer, 2008).

Conceptual framework development

As to the ways in which consumers adopt innovations, this phenomenon has been studied from a variety of perspectives (Ronteltap et al., 2007). Wide-ranging research into the acceptance of technology-based innovation has generated a new conceptual framework focused on identifying and locating the attitudes and behavior of consumers in relation to such new technologies (Cardello, 2003a, 2003b). As reported by Ronteltap et al. (2007) in their review, research can generally be regarded as stemming from two distinct spheres, namely macro research including work in the fields of sociology and economics and micro research focusing on individual behavior by consumers, perceived risk and outlying trends underpinned by psychology.

On a macro level, established economic models tend to focus on a cost/benefit analysis with focus on the relative benefits as perceived by society or in terms of economics. This includes studies involving the measurement of risk as opposed to the benefits, social or otherwise, obtained from a specific process. Such analysis, while more generic in its nature, is of relevance to innovation inasmuch as it places emphasis on the balance between costs and benefits as a critical factor in determining consumer behavior and acceptance of innovative products and practices.

Within innovation theory more broadly, the cost/benefit trade-off is central in terms of defining models for acceptance and the likelihood of consumers perceiving innovation as appropriate along with their ultimate acceptance or rejection. Personal consideration based on such a balance proves highly significant in determining behavior.

As reported by Ronteltap et al. (2007) in the mentioned study, innovation and its diffusion have long been studied within the sphere of sociology and may be traced back to early studies of developments in early industrial processes and agriculture, studies that focused on adoption rates relating to new innovation, the corresponding curves that depict their acceptance among social groups and the rates at which groups of consumers may accept the innovation in question. Such ideas were specifically developed by Rogers (1995, 2003), whose work on innovation provided a fresh perspective on the dissemination of innovation, in turn providing a solid theoretical base for further research. His theory of diffusion describes the process of innovation dissemination and how this process functions in terms of both timescales and within various social groups and systems. The theory is based on four principal categories: adopter categories, communication, the individual decision process and the identification of characteristics inherent to an innovation. This is followed by classification of individuals in terms of how quickly or otherwise they are likely to accept and adopt an innovation into classes of “innovator categories” based on the relative speed at which innovation is adopted by various individuals. The second category of communication describes how individuals become informed and knowledgeable of a various innovation, the individual-decision process describes the process by which initial knowledge is transformed into an attitude, a decision to adopt or reject, the implementation of an idea and, finally, confirmation of the decision made. During this process, the uncertainty of an individual relating to a particular innovation is gradually removed. Such a process of removal takes place at different speeds for different individuals and the differences of such adoption rates are particularly significant within the research itself. Characteristics of innovation that may explain such differences include: relative advantage, compatibility, complexity, trialability and observability (Rogers, 2003; Nacarrow et al., 2009; Ronteltap et al., 2007).

The work of Rogers and related theories thus conclude that the potential rate at which an individual may adopt innovation depends upon a range of specific functions including those inherent to the innovation itself, to the individual, the information provided in order to describe innovation and the quantity of information disseminated within social spheres. This theoretical perspective provides a general concept of innovation dissemination although lacks more specific examples and does not specially cover cases of innovation or technology in food.

In the specific field of food technology and innovation, perceived risk and uncertainty are considered as significant factors. This would appear reasonable considering the intimate relationship that consumers have with food (Ronteltap et al., 2007). Furthermore, food technologies present some of the most typical characteristics which appear to generate concern amongst consumers including the perception of new technology as beyond our control, that may bring about harm and, ultimately, prove fatal (Miles and Frewer, 2001). Moreover, this notion appears to be based on the fear of the “unknown” and unobservable aspects of food innovation. Such fears may be aligned with the notion of credence qualities, factors which consumers are unable to distinguish in their personal experience including safety, sustainability, health and naturalness. These qualities are seen as generating risk specifically in cases where information is lacking. This is, in turn, mediated by levels of trust in regulators who thus play a critical role in forming perceptions. A number of psychometric studies focus on consumers relationships towards hazards seen as broadly centring around two dimensions: dreadfulness (the most significant factor) and the extent to which a hazard is judged to be unknown (Ronteltap et al., 2007). These two factors provide a perspective through which hazard rates may be quantified in order to
assess perceived risk which, in turn, leads to consumers desiring that risk be reduced and that more rigorous regulation be introduced in order to reduce such risk. Miles and Frewer (2001) demonstrate that consumer concerns with food risks are significant in terms of acceptance levels. Furthermore, Slovic (1987) demonstrates that a hazard is perceived as presenting more risk when experts are seen to be unable to provide appropriate explanations as to the potential consequences of a hazard. This leads to a sense amongst consumers that risks are somehow being “hidden” by the scientific community. This is furthermore compounded in situations in which information is ambiguous, overly technical and inconsistent, leading to certain management strategies by consumers in order to avoid certain information, thus perceiving negative aspects of innovation as a cost or a risk.

In order to set a comprehensive framework including the many facets of the process of acceptance and adoption of consumers, this review adopts the conceptual framework developed by Ronteltap et al. (2007); such a framework allows to reflect the present situation of consumer attitudes and acceptance of food technologies based on their ultimate intention to use innovation in food or not. This is based on distinguishing distal or primary determinations (features of the innovation, characteristics, social characteristics) and proximal or secondary ones (adoption based on perceived benefits, risk, subjectivity norms, perceived control). These are permeated by communication which connects innovation to perception amongst consumers. In addition, this review adds to the described framework and investigates relevant psychometric models, above all the Food Technology Neophobia Scale (FTNS), as valid tools to analyse consumers’ perception and potential behavior.

The framework proposed thus attempts to integrate work already carried out in the field of consumer acceptance and innovation, using the attitude or psychometric models as its base. It is also recognised that general attitudes play a significant role in shaping consumer attitudes. Reviewed research is incorporated, focusing on the proximal and distal elements underpinning acceptance and mediated by communication. A discussion thus follows of the key elements of the determinants described in an attempt to consolidate the framework in light of the sometimes more abstract notions provided by mentioned existing research.

Flow Conceptual Framework Submission

Previous empirical research into proximal or secondary determinants

Perceived cost/benefit considerations

The majority of research reports benefit perceptions as critical to consumer acceptance. Adoption behavior has been revealed specifically in the case of research into high-tech innovation; in the case of food acceptance, distinction is made between benefits for consumers themselves and benefits to society more generally (Koster, 2009). Several areas of benefits may be identified including innovation use, sensory elements, health, the environment and production methods (Urala and Lähteenmäki, 2007; Chen, 2007). Much research expresses benefits in terms of usefulness, compatibility, ease of use and trial-ability, as described by Rogers (2003) (Nencarrow et al., 2009; Ronteltap et al., 2007). Sensory aspects such as appearance and taste are especially significant in food studies and feed into expectations regarding quality, thus enhancing positive influences on health of a particular product. (Pliner and Salvy, 2006; Chen, 2007). As regards functional food, for example, there is also a perceived reward for using it that may over time affect overall evaluations of products themselves (Urala and Lähteenmäki, 2007; Dolgopolova et al., 2015). Perceived costs and benefits are thus demonstrated in both food and non-food research to be a significant factor in consumer acceptance and include both individual benefits (use, health) and social benefits more generally (resolving food shortages, facilitating healthier lifestyles) (Varble and Secchi, 2013; Chen, 2007). Consumer perception is not however necessarily in line with the actual technical benefits and cost of the innovation itself (Nencarrow et al., 2009; Urala and Lähteenmäki, 2007; Pliner and Salvy, 2006; Varble and Secchi, 2013).

Perceived risk and uncertainty

Risk and uncertainty are critical factors affecting consumer attitudes, as demonstrated in a number of studies (et al., 2016; Jang and Kim, 2015; Chen, 2007; Vermeau et al., 2014). This is also due to the nature of food innovation and the difficulty for consumers in assessing real risk which may be uncertain and only perceivable in the long-term (Hunt and Frewer, 2001). As argued by Ronteltap et al. (2007),
interplay is also demonstrated between cost/benefit perceptions and risk (Jang, and Kim, 2015). Risk has been somewhat difficult to define concretely in several studies while others have differentiated between specific risks e.g. health, environmental risk perception etc. (Chen, 2008; Baker et al., 2016; Lease et al., 2014). Various studies have focused on current risks to health or the environment and future risk (Slovic, 1987); other factors influencing perception in terms of risk include the right to be informed and attitudes to sensitive information (DolGOPOLova et al., 2015; Deroy et al., 2015). Feelings of anxiety and dread relating to specific food innovation have also been shown to positively influence risk perception, particularly in the case of GM food products and nanotechnology applications (Schnettler et al., 2013; Hartmann et al., 2016; Schnettler et al., 2013; Matin et al., 2012). Risk is also affected by the concept of trust, namely in experts, health officials and producers (Hartmann et al., 2015). Acceptance is thus strongly linked to consumer trust as shown in studies of various food innovations (GMF, irradiation, additives and pesticides) as well as beyond the field of food (Hunt and Frewer, 2001; Jang, and Kim, 2015; Baker et al., 2016; Slovic, 1987; Deroy et al., 2015; Megido et al., 2014; Chen, 2007). Risk is thus shown to be significant in determining levels of consumer acceptance of food innovation and specifically in the areas of safety issues, consumer concern, trust and emotions (Verbeke, 2015; Tan et al., 2015).

In the context of perceived risk and uncertainty, a relevant study was conducted by Lease et al. (2014), analyzing perceived hazard and consequent emotions related to specific food ingredients; they researched consumers’ acceptance of 4 samples of recycled water (A-Ingested, B-Mid-proximity, C-Distant-proximity and D-control) in meat products (meatballs) and the influence of tasting, attitudes and values on hedonic and emotional reactions. The result was that neophobia is associated with low hedonic ratings, and low positive and high negative emotional reactions to products with higher proximity to ingestion; the research concluded that food experiences are multidimensional, with positive/ negative emotions felt simultaneously to a greater or lesser degree. Positive emotions, desire ‘satisfaction enjoyment pleasant surprise’ were strongly experienced. ‘Disgust’ and ‘fear’ least experienced. As regards the moderating effect of variables that will be further discussed, the socio-demographic characteristics minimally impacted hedonic responses, low income associated with low hedonic scores for the two highest levels of proximity to ingestion; ‘fear’ influenced by age was minute. It was expected that neophobic tendencies associate risks with using recycled water and are uncertain about the safety, benefits and quality of the food. The results indicated that neophobia was not related to hedonic/ emotional reactions. Other studies (Hurllmann, 2008; Marks et al., 2008; Nancarrow et al., 2009) indicated that trust would be a significant factor in acceptance of recycled water for personal uses (Cox and Evans, 2008; Frewer et al., 1996). Hunt and Frewer (2001) noted communication of recycled water benefits from an ‘independent credible trustworthy source e.g. government entity (food regulator) or science agency (CSIRO). The study concluded consumers were to accept/willing to try foods containing or in close proximity to water collected, treated and returned to drinking water standards. Although there was insufficient evidence for food companies to gain brand strength using recycled water, the study shows consumers would not reject products, if supported by a credible and trustworthy source of information.

Perceived behavioral control and subjective norm. The theory of planned behavior and environmental attitudes

Perceived behavioral control, the attitude of others and subjective norms have all been shown to be influential in consumer acceptance or rejection of innovation (Jeżewska-Zychowicz, 2009a, 2009b; Kim et al., 2014). This is underpinned by the fundamental concept of self-efficacy, as demonstrated in a number of studies (La et al., 2016; Baker et al., 2016). While not receiving significant attention in the literature on food innovation acceptance, social pressures have been shown to mediate consumer attitudes in non-food fields such as technology (Ronteltap et al., 2007). It may be assumed that social pressures, peer-group attitudes and the influence exerted by people of influence (e.g. an employer) exert specific social pressures and that food, in itself a social sphere, is thus no different (Siegrist et al., 2007). Perceived behavioral control and subjective norms are thus considered as significant factors in food innovation acceptance (Chen, 2007; Jeżewska-Zychowicz, 2009a, 2009b; La Barbera et al., 2016; Stratton et al., 2015; Siegrist et al., 2007; La Barbera et al., 2016), albeit an area requiring further in-depth empirical research more specifically in the field of food innovation.

In this context a relevant contribution is provided by the Theory of Planned Behavior (TPB) (Kim et al., 2014); according to this theory, human action is led by three kinds of beliefs: the behavioral beliefs, the normative beliefs and the control beliefs.

A behavioral belief develops the individual’s attitude toward the behavior; a normative belief produces a subjective norm and a control belief is related to perceived behavioral control, which may be influenced by other factors. The TPB shows that attitudes, the subjective norm and perceived behavioral control are all factors capable of predicting the behavioral intention; roughly speaking, the stronger the individual’s intention is, the more he or she will perform that behavior.

Even if the TPB has known a great popularity thanks to its general reliability and has been greatly applied in consumers’ research, it has been criticized due to its lack of consideration concerning the affective aspects of attitude, considering only the rational and cognitive factors, as reported by Kim et al. (2014).

As a result and in order to enhance the predictive power of the TPB, various studies have tried to include additional constructs; as an example, past research has concluded that a person who does not have a positive or negative attitude toward a certain behavior can be persuaded to behave differently, or has made reference to the so called “perceived need”, the degree to which an individual feels the need to perform a behavior, feeling that, in turn, influences his or her intentions of the behavior itself.

As regards more specifically food choice, past research making use of the TPB has focused particularly on environmental attitudes, showing that consumers who consider themselves “green”, that’s to say, those who have a stronger environmental friendly self-identity, have stronger intentions in buying organic food because of their moral attitudes and subjective norms (Arvola et al., 2007; Dean et al., 2012).

These moral norms help them in “doing the right thing”, for animal welfare, environmental and ecosystem issues; it has been shown that people who are more concerned about environmental issues are more likely to show off environmentally friendly behavior.

The importance of understanding the consumers’ motives leading to specific food choices, and in turn to purchase intentions, is addressed as well with reference to organic food (Chen, 2007); by means of the above mentioned Theory of Planned Behavior, the author investigates those individual’s food-related personal traits of food neophobia and food involvement separately capable of having a moderating influence on personal food choice, with particular reference to organic foods in Taiwan. The study reaches the general conclusion that both mentioned food-related personality traits have a moderating role in affecting the relationships between some of the food choice motives and consumers’ attitude to organic products, while only food involvement influences the relationships between consumers’ purchase intentions and the above mentioned beliefs of the TPB, except for the cited subjective norm or normal belief. The author (Chen, 2007) provides as well some suggestions to the institutions involved in the study aimed at enhancing the organic sector’s expansion in Taiwan’s food sector.

Perceptions of new food technologies can be affected as well by the degree of naturalness in food production (Siegrist, 2008); as stated by
Hosseini et al. (2012) this is due to the potential increase in the sustainability of the food industry deriving from the application of new environmentally friendly technologies in food production and processing. As a consequence, consumers’ behavior seems to become more ecologically conscious in those individuals showing a higher level of environmental concern (Hosseini et al., 2012). This becomes particularly interesting with reference, on the one hand, to the perceptions and purchasing intentions of Genetically Modified (GM) products, often less favored due to the trade-offs in terms of risks and benefits of the greenhouse effects, as well as in terms of health concerns (Kim et al., 2014). On the other hand, increased environmental awareness has a positive effect on the buying of organic foods (Chen, 2007) as well as a positive moderating influence on the acceptance of nanotechnology applications in food industry (Matin et al., 2012; Sodano et al., 2016; Giles et al., 2015). As reported by Hosseini et al. (2012), different environmental scales, called New Environmental Paradigm (NHP), are used as explanatory variables of environmentally protective behavior, they include ecological beliefs, personal norms and eco-altruistic values, all with the aim of predicting the influence of the mentioned variables on consumers’ behavior.

As increasing attention is paid to the conservation of nature, to a wiser use of resources, to ecology, and to the wellbeing of present and future generations, the mentioned issues need to be addressed by enforcing changes in human behaviors and in society (Matin et al., 2012). As well, governments should establish a clear set of rules regarding what is or is not allowed, in order to enhance trust and credibility from consumers in the food industry.

**Previous empirical research into distal or primary determinants**

While distal determinants are relatively straightforward in terms of measurement, they may be unable to fully explain relationships in that their effects are mediated by a range of other consumer perceptions (La Barbera et al., 2016). The framework proposed distinguishes between features of the innovation under study (e.g. price), those who may adopt such innovation (e.g. age groups) and the social context within which the innovation is located (e.g. collective culture etc.) (Nancarrow et al., 2009; Chung et al., 2012; Jang et al., 2015).

**Innovation features**

Innovation features are demonstrated to influence acceptance, particularly in the case of behavior within the field of food innovation (Dekkers et al., 2006; Evans and Cox, 2006; Van Wezemael et al., 2014; Sudbury and Simcock, 2009; Barrenet et al., 2015; Cardello et al., 2007). These include basic features such as price, complexity, convenience, taste and appearance. In the case of food and its relationship to health and disease prevention, food types and branding demonstrated a positive influence on purchase behavior (Cardello, 2003a, 2003b). Genetic modification was considered the least acceptable innovation while traditional methods were considered the most acceptable (Dekkers et al., 2006; Chen, 2007). The type of modification is also shown to affect consumer behavior with modification resulting in enhanced flavour, enhanced nutritional value or pesticide reduction shown to have a positive influence on purchasing decisions (Chen, 2007; Evans and Cox, 2006). Such features are not, however, necessarily separable from consumer perception (Van Wezemael et al., 2014; Fenko et al., 2015a, 2015b). Existing research confirms that consumer acceptance is primarily mediated through proximal perception e.g. cost/benefit and risk (Ronteltap et al., 2007; Sudbury and Simcock, 2009).

**Consumer characteristics. The Food Technology Neophobia Scale and The Means-end chain (MEC)**

Socio-demography provides easily measurable variables yet low levels of explanation in terms of consumer acceptance (Ronteltap et al., 2007). Various socio-demographic trends on innovation acceptance such as lower perceived risks amongst white males as compared with white females or non-white individuals may be explained by broader socio-political factors such as worldviews (Choe, 2011; Labrecque et al., 2006). Knowledge and expertise have been demonstrated to be influential variables in risk perception yet while expertise increases risk perception, knowledge is found to have a positive impact on acceptance (Villegas et al., 2008). Furthermore, while knowledge of food safety positively affects the decision to buy irradiated products, scientific knowledge has a negative effect in terms of biotechnological innovation (Verneau et al., 2014). Broader research into the effects of knowledge on consumer behavior is shown to be complex, with existing relevant knowledge shown to have a positive impact in the case of continuous innovation. However, discontinuous innovations prove more complex in that supplementary knowledge is also necessary in order to affect a positive relationship (Steinka, 2009; Ronteltap et al., 2007). Further psychological determinants and general world outlooks such as universalism etc. demonstrated both a positive and negative impact on attitudes and acceptance (Siegrist et al., 2015; Fenko et al., 2015a, 2015b). As regards general attitudes, much existing research has classified them into groups such as: socio-demographics, knowledge, personality and general attitudes or values (Van Wezemael et al., 2014; Chen, 2007). Such classification provides a solid basis for the analysis of consumer acceptance (Villegas et al., 2008; Verneau et al., 2014; Steinka, 2009; Siegrist et al., 2015; Van Wezemael et al., 2014; Frandsen et al., 2007; Sabbe et al., 2009) as examined through the adopted framework.

**The food technology neophobia scale**

As argued in the introduction, consumer trends in a globalized market are twofold: on one side, a growing demand for modernity (functional and healthy foods), on the other side, there is a request for natural foods (organic, natural, typical and local foods). Innovations in the food industry are often not well accepted by the market, partly due to the mentioned phenomenon known as neophobia; indeed, neophobic people have negative attitudes and lower expectations regarding the taste of foods (Barrena and Sanchez, 2012; Henriquez et al., 2009). In the conceptual framework of this review, the importance of the FTNS lies in determining receptivity to foods produced by different technologies. Developed by Cox and Evans (2008), the FTNS identifies neophobia in relation to food technology. The overview of its development is vital to the understanding of all the factors underlying consumers’ attitudes.

This tool was developed to measure the acceptance limits of foods produced by new technologies by identifying segments of the population that have a different degree of neophobia, identifying groups with positive attitudes towards food produced by new technologies can be helpful, especially when such foods provide benefits (Evans et al., 2010).1

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1 The FTNS was developed As part of a broader national research program (Food Futures National Research Flagship Project, www.esiro.au/FoodFutures) involving the development of novel foods and food technologies. Face validity, convergent validity and predictive validity were analysed with the following objectives: create a tool capable of identifying consumer segments embedded with the willingness (or not) to try foods produced by novel technologies; test a concise set of stimuli (statements that consumers can agree or disagree with, measured on a 7-point scale anchored disagree–agree) relating to possible reactions to different food technologies; test a scale aimed at predicting variance in consumers’ willingness to purchase and consume foods obtained by means of novel technologies; test a scale for convergent validity through measurement of associations with the Food Neophobia Scale (FNS; Pliner and Hobden, 1992), General Neophobia Scale (GNS; Pliner and Hobden, 1992) and Trust in Science Scale (TSS; Bak,
In their study, Cox and Evans (2008) adopted a three stage approach, and included as well the GNS (General Neophobia Scale; Pliner and Hobden, 1992), FNS (Food Neophobia Scale; Pliner and Hobden, 1992) and TISS (Trust in Science Scale; Bak, 2001) were also included with the hypothesis that the FTNS may reflect “phobic attitudes to food technology” similar to the “phobic attitudes to food” as measured by the FNS (Cox and Evans, 2008). As well, the GNS was used to assess the degree to which “phobic attitudes to food technologies” reflect a more general phobic behavior trait. Finally, as science is deeply involved in the development of new technologies, correlation was sought with the TISS in order to evaluate individuals’ perception of the role of science (De Steur et al., 2015; Matin et al., 2012; Mueller, 1986).

The 3 Stages approach adopted required the assessment of the stability of the FTNS, resulting in a positive evaluation of the number of factors and the grouping of factors between the data collected from each different Stage, as well as of the consistency of the same data from one stage to the other. All this can be considered as a confirmation of the development of a stable and valid measure of technology neophobia and of “attitudes to new food technologies”, having a good reliability and convergent validity, as it correlates with other instruments used to measure similar issues, such as the TISS and FNS; the FTNS demonstrates to be a better instrument for predicting individuals’ willingness to approach foods produced using novel technologies than the other mentioned scales. Moreover, in light of the correlations between the FTNS and the “Willing to Try” scales, it has a relevant predictive validity (Vidigal et al., 2015; Siegrist et al., 2014).

As to the four FTNS components, the first component identifies the connection between perceived risk and technologies (Perceived risk): the more it increases, from negative to positive values, the more consumers perceive technology as being hazardous (Coppola et al., 2014); this component can be considered as a scale of risk and its meaning is also related to the belief that society should not consistently rely on technologies to solve food safety issues. As food security is a key problem for society, technologies are seen as fragile and unreliable to depend upon; this is as well shown by the statement “There are plenty of tasty foods around, so we do not need to use new food technologies to produce more”, adding an ideological connotation to the mentioned first component; moreover, the perception of technology as risky, in relation to the uncertainty associated to food technologies, allows a more transversal correlation with other components.

The second factor allows identification of the opinion of respondents concerning the usefulness of new technologies and their level of uncertainty (Uselessness of Technology component); the higher and positive its value, the more consumers do not recognize relevant benefits deriving from the introduction of new food technologies, and they perceive uncertainty (“New food technologies are something I am uncertain about”), whereas negative values of the component relate to consumers belief that new technologies bring about more benefits in terms of healthy nutrition, food quality and taste (Vidigal et al., 2015). The third component (Benefits and health effects) is positively correlated with the capacity of new food technologies to be beneficial in terms of control over food choices and possibility to have a balanced diet and positive health effects. The fourth component (Trust in media role) refers to aspects of the role of media in conveying information on food technology; it is positively correlated with consumers’ belief that, in general, the media provide reliable and unbiased information, especially with potential long-term negative health effects (Evans et al., 2009).

The Means-end chain (MEC)

As to the main reasons why human beings reject food, i.e. aversion, danger, disgust (Verneau et al., 2014; Vidigal et al., 2014), these psychological categories are the basis for the analysis of the acceptance or the rejection of different foods. Tests have been carried out to evaluate neophobia such as tests about the willingness to try unfamiliar foods (Fenko et al., 2015a, 2015b; Giles et al., 2015; Verneau et al., 2014) or food preference tests (Hoek et al., 2011; Jang and Kim, 2015; Chen et al., 2013; Jezewska-Zychowicz, 2009a, 2009b; Giacalone et al., 2014). Some results are that information about good taste increases willingness to try them (Kergoat et al., 2010; Hoek et al., 2011) as well as a certain familiarity of the food to be consumed (Jezewska-Zychowicz, 2009a, 2009b; Jang et al., 2015); since there is little research on the relationship between the different cognitive structures of consumers and the levels of food neophobia, Barrena and Sánchez (2012) have tried to analyze if and how the cognitive structure of neophobic consumers varies according to the type of food they are exposed to. Their study is based on the so-called theory of the means-end chain (MEC); it consists in stating some relationships between the features of the products, the positive aspects they arise in the consumers’ mind and the usefulness that consumers try to get using them.

Gutman (1982) was the first to use the means-end chain theory to explore how consumers’ knowledge of products can be linked to their knowledge of the consequences and the usefulness on their personal life and health; at the basis of the MEC there’s the idea that consumers learn how to select those products that give them the possibility to get some personal benefits and some final values. Through a series of interviews conducted with a specific technique named “laddering”, the authors tend to highlight the consumers’ idea of features, consequences and usefulness associated to a particular product. The way these ideas are associated is used to generate hierarchical value maps (HVM), that show the following results: 1) the cognitive structure of consumers does not show any degree of neophobia with products that are consumed regularly; 2) the cognitive structure of non-neophobic consumers is the same both with new products and with traditional ones; 3) foods’ concrete attributes are given more importance than the abstract ones: for example consumers rely on “label information” and seem to be more willing to try new foods if they have enough information about them. Ideas related to the quality of each product are also important, as well as some abstract ones concerning their instrumental value (e.g. “this food improves my quality of life”). Abstract attributes and psychological consequences prevail over concrete features with neophobic consumers, together with personal associations in the purchase process. That is, neophobic consumers show a higher level of abstraction because they tend to transfer their personal values to the features of the product during the purchase process. In other words, when deciding to purchase new foods, consumers who are more reluctant to try new products tend to mix their personal values with the characteristics of each product, thus making the choice process more complex: a more mediated choice means more fear and more neophobia.

Social system characteristics

Social characteristics may potentially determine acceptance of innovation (Sabbe et al., 2009; Van Wezema et al., 2014; Hoek et al., 2011; Gutman, 1982; Dolgopolova et al., 2015; Coppola et al., 2014; De Steur et al., 2015; Gibson, 2006; Hartmann et al., 2016; Jang and Kim, 2015; Fenko et al., 2015a, 2015b) despite not having been studied in great depth (Fenko et al., 2015a, 2015b). However, social characteristics are seen as significant considering that innovation is always dependent upon the social context in which it is developed (Fenko et al., 2015b; Grunert et al., 2003; Rogers, 1995, 2003; Chung et al., 2012). Examples of such influence are provided by the ability of experts to communicate information on innovation in the social context of reference (Hoek et al., 2011), social trust by consumers in
innovation decision-makers and shared values, religious beliefs and their influence on consumer behavior in either the acceptance or rejection of certain products on the basis of offensiveness, particularly if the innovation is seen to be “playing God” as in the case of GM (Sabbe et al., 2009; Chen, 2007). However, while social characteristics are clearly significant, they have received limited attention in the field of research on innovation acceptance (Rogers, 1995).

**Previous empirical research into communication**

Communication is highly significant in terms of linking distal and proximal characteristics in that it determines how such innovation is ultimately received (Baker et al., 2016; Almli et al., 2013; Fenko et al., 2015a, 2015b; Deegan et al., 2015). This refers not only to a simple exchange of information but also to questions of perception and judgement, of specific importance in the case of controversial innovation (Frewer and Salter, 2002; Chen, 2007). Several factors determine the importance of communication: firstly, the source of the information itself, as trusted source generally leads to positively influencing attitudes (Villegas et al., 2008; Deegan et al., 2015; Fischler C, 1988; Kergoat et al., 2010; Lampila et al., 2009; Lusk et al., 2014; Megido et al., 2014). It has been demonstrated that interpersonal communication is more effective than media or impersonal information campaigns in terms of consumer behavior (Villegas et al., 2008).

The quantity and nature of the information is also highly significant (Van Wezemael et al., 2014; Villegas et al., 2008; Arvola et al., 2007; Chen, 2007; Chen et al., 2013; Deegan et al., 2015). Clear food labelling information in the case of food innovation technology has been shown to generate more positive attitudes (Fischler C, 1988). Likewise, safety information and handling information has been shown to increase acceptance and food presented with positive information positively affecting consumption and negative information negatively affecting consumption, as does a combination of positive and negative information (Kergoat et al., 2010). The quantity of information, visual exposure to products and statements on safety have been shown to affect behavior (Baker et al., 2016; Lampila et al., 2009). Quantity has a positive influence particularly in the case of familiar products (Lusk et al., 2014); some evidence has demonstrated that in the case of GMFs, increased information has a negative influence on consumer attitudes (Megido et al., 2014); as media focus on the risks of GMFs produced higher risk and lower benefit perceptions (Chen, 2007; Chen et al., 2013). Risk uncertainty also affects consumer attitudes with the admission of risk uncertainty found to improve consumer attitudes towards GMFs (Van Wezemael et al., 2014). Consumer confidence in information and an interest in food production information is also critical in terms of consumer acceptance (Villegas et al., 2008).

The distal characteristics previously outlined are significantly affected by communication including its source, type and amount of information (Fenko et al., 2015a, 2015b; Frandsen et al., 2007; Ghawi et al., 2014; Haugaard et al., 2016; Verneau et al., 2014; Sodano et al., 2016; Sabbe et al., 2009) ultimately determining the adoption of innovation (Arvola et al., 2007). This is particularly true in cases in which consumers must rely on judgement rather than certainty (Chen, 2007).

**The case of consumer acceptance of the eating of insects**

Entomophagy, the practice of consuming insects, has a complex relationship with consumers permeated by various cultural contexts (Caparros Megido et al., 2013; Vanhonacker et al., 2013). While in industrialised, generally western societies, the practice has a long history of rejection due to cultural norms, perceptions of disease, low taste expectations and a general unwillingness to consume (neophobia) based on disgust, in many societies and cultural groups around the world, for instance in Asia, Central America and Africa, insects have long formed, an albeit limited, part of the traditional human diet (Hartmann et al., 2015). However, even in communities where the consumption of insects is culturally rooted in culinary traditions and practice, also due to the perceived health benefits that insect protein may bring (Verkerk et al., 2007), such practices are also changing with the introduction of more westernized diets (Ramos-Elorduy, 2009).

However, experts in the field underline the potential value of insects in human food production from a variety of perspectives; firstly, increases in the demand for food globally and food shortages, specifically due to the challenges presented by growing populations which could in some way be alleviated by the introduction of the alternative protein sources provided by insect species (Belluco et al., 2013; Van Huis et al., 2013). Secondly, many insects present high nutritional value in terms of their protein content, vitamins, minerals and low cholesterol concentrations. Furthermore, insects provide a sustainable food production alternative to animal proteins with lower production costs, lower environmental impact (Oninxc et al., 2010) and a better biomass conversion rate (Lowe et al., 2008; Falguera et al., 2012).

Several studies have thus focused on the willingness on the part of consumers within different cultural groups both to consume insects and include them as part of a regular diet, investigating as well psychological factors affecting consumption and purchase intentions (Baker et al., 2016); this review focuses on major studies, including a cross-cultural comparison between German and Chinese consumers (Hartmann et al., 2015) and other investigations into the attitudes of western consumers (Caparros Megido et al., 2013; Ali, 2016; Verbeke, 2015; Tan et al., 2015), have attempted to locate some of the most significant drivers impacting the attitude of consumers, their motivations for acceptance or rejection and the probability of the willingness to introduce insects as a part of their regular diet. Such drivers determining this complex relationship include, although are not limited to, cultural influences, beliefs and social norms, visual appearance, taste expectations, a sense of “animalness”, whether the product is processed or unprocessed, whether the product is presented as the dominant food or combined with alternative ingredients already accepted within that culture (e.g. chocolate) or within drinks etc., the perceived health value of the product, previous experience of eating insects, demographics such as age and gender (Verbeke, 2015; Tan et al., 2015).

The consumption of insects in western society is highly limited, with insects rarely ingested (Ali, 2016) only as a novelty, while in mainly cultures, China, for example, insects are seen in a more positive light and are accepted as providing health benefits to consumers. The most significant differences revealed by the studies relate to the following fields: firstly, the type of species presented inasmuch as consumers may have culturally loaded expectations of consumption when presented, for example, with a whole cricket rather than a butterfly. Secondly, consumers demonstrated significant differences in terms of food type; western consumers were more likely to accept insect-based products when they were presented as ingredients of more generally accepted processed foods (e.g. cookies or drinks) rather than unprocessed (Hartmann and Siegrist, 2016; Ali, 2016), while eastern (above all Chinese) consumers revealed little differences in terms of their acceptance based on this factor. Significant differences were also revealed in cross-cultural differences in terms of taste and nutritional value acceptance as well as social acceptance with eastern countries demonstrating more positive attitudes, presumably based on their long cultural inclusion of insects as part of a traditional diet with perceived health benefits (Hartmann et al., 2015).

A final factor identified by the research indicates that high values for food neophobia and negative taste expectations alongside low social acceptance or no previous experience of eating insects has a significant effect on acceptance levels amongst all of the cultural groups examined.

Demographic trends arose in both studies with men generally demonstrating slightly greater acceptance than women and older age
groups demonstrating slightly more knowledge of Entomophagy and, accordingly, higher acceptance levels than younger age groups (specifically in the Belgian study). Education did not appear to have any significant effect on acceptance levels.

The work of Caparros Megido et al. (2013) demonstrates generally positive results inasmuch as respondents demonstrated a higher level of willingness to consume insects in the future following the research. This demonstrates a move away from considering insects as a “novelty” food and is also impacted by a raised awareness of further benefits provided by insect consumption such as lower environmental impact and sustainability issues.

Generally, the research provides insights into the somewhat entrenched attitudes of particularly western consumers in insect consumption yet does shed some light on future directions for research which may prove useful for identifying the most significant factors impacting the willingness or otherwise to consume such products, thus providing indications for pathways towards greater acceptance in order that insects may be introduced as an alternative protein source to meat production, thus reaping positive effects in terms of environmental impact, sustainability and nutritional health benefits.

Conclusions

This systematic review analyses and synthetizes the main results of recent studies dealing with food neophobia and neophilia with regard to new technologies applied to the food sector, both in the context of developed countries and in developing ones. In particular, main factors leading to caution and aversion for food technologies were identified and discussed, as well as different approaches to measure consumers resistance to the mentioned technologies and to predict consumers’ behavior.

As argued, in recent years, the number of new foods has increased as a result of new food technologies; the advantages of such technologies are multifarious and include safer, healthier and more nutritious foods using less energy, water and chemicals and producing less waste (Rollin, Kennedy, and Wills, 2011), the enhancement of environmental sustainability (Matin et al., 2012) and the growth of food productivity. Moreover, nowadays consumers are more and more aware of their food selection (Lindeman & Vaananen, 2000), especially novel foods. They are more demanding for the quality of the products and health benefits they produce (Barrena and Sánchez, 2013), in fact, they are aware of the effects of nutrition on health and well-being (Pounis et al., 2011). As a matter of fact, foods should be meant as a weapon to prevent nutrition-related diseases and improve physical and mental well-being (Siro et al., 2008). Thus food market must create new competitive products, nutrient-enriched, or produced by using new technologies in order to satisfy consumers (Siro et al., 2008; Barrena and Sánchez, 2013).

As a matter of fact, consumers have a variety of attitudes and preferences toward different, novel food technologies (Frewer et al., 2013; Pliner and Salvy, 2006; Ronteltap et al., 2007), which may influence their food choices.

Even if food technologies have developed as a result of market needs, consumers are suspicious of new technologies because of the lack of perceived benefits (Vidigal et al., 2015; Cox et al., 2007; Frewer, Bergmann et al., 2011). Nowadays, consumers are exposed to the different techniques of emerging technologies, including genetic modification (GM foods), food irradiation and nanotechnology (Rroll et al., 2011; Siegrist, 2008). However, caution and aversion for food technologies is widespread in different countries, both developed and developing ones (Bäckström, Piirttilä-Backman and Tuorila, 2004; Cardello, 2003a, 2003b; Cardello, Schultz, and Lesher, 2007; Cox et al., 2007; Siegrist, 2008; Siegrist et al., 2007). As an example, despite the positive attitude of the scientific community, the preservation technique and food irradiation are not accepted by consumers (Ronteltap, Van Trijip, Renes, and Frewer, 2007). The degree of acceptance of new technologies applied to food production changes from country to country; with reference to genetically modified food, as argued, American consumers tend to be more positive than European and Japanese costumers (Gaskell, 2000; Lusk et al., 2003). Schnettler et al. (2013) underline that, in general, developing countries show positive feelings towards genetically modified foods, such as Brazil (Da Costa et al., 2000), China (De Steur et al., 2010) and Kenya (Kimenu and De Groote, 2008); nevertheless, in other developing countries, perceptions are not so positive, as is the case of Argentina (Mucci et al., 2004) and Chile (Schnettler et al., 2012).

As mentioned regarding applications of nanotechnology, the public opinion is not clear-cut and there are a few researches on its perception by consumers (Chaudhry et al., 2008; Matin et al., 2012; Siegrist, Stampfl, Kastenholz, and Keller, 2008); investments from government agencies and industry might contribute to the development of this sector (Frewer et al., 2011). Recent studies conducted in European countries highlight that consumers are still suspicious about eating food produced using nanotechnology and consumers’ attitudes are a key factor of new technologies as regards its success or failure in the marketplace (Bieberstein et al., 2013; Siegrist et al., 2007; Stampfl et al., 2010; Frewer, Bergmann et al., 2011; van Kleef et al., 2005). Thus, future researches on new technologies should include a psychology dimension to investigate and identify the real factors that determine consumer behavior, so as to predict their choice of specific food (Koster, 2009).

As firms attempt to put in place effective product development strategies and processes, it is vital to recognize how newness “per se” does not guarantee positive market performance (Van Trijip and van Kleef, 2008); this occurs if newness itself provides real and meaningful differentiation to consumers in the market place. As already mentioned, humans are equipped with two opposite though co-existing tendencies: the curiosity towards novelty and the consequent tendency to try new and unfamiliar foods (neophilia), and the prudence with respect to new food products (neophobia), perceived as being dangerous if not poisonous (e.g. mushrooms). As a reflection of the omnivore paradox (Fischler, 1990), this ambivalence leads to an overall preference for new food products with moderate levels of newness, capable of generating consumers’ interest and avoiding excessive fear (Van Trijip and van Kleef, 2008). The high level of “intimacy” related to food is at the basis of consumers’ precaution (Ronteltap et al., 2007; Koster E.P., 2009) and the attempt to balance newness against meaningfulness; as a consequence, food marketing and food New Product Development face the challenge to find an optimal level of the mentioned newness, high enough to induce curiosity and willingness to try the new food, but low enough not to cause neophobia. Future research is needed to set this optimal level and to investigate how market success and performance are related to product newness (Gielen and Steenkamp, 2007).

Furthermore, taste can be defined as the specific sensory function related to the flavour of food; apart from its physiology, mainly due to nerve cells, taste is, among all the five senses, the only one endowed with a social component. If it is conceived as the set of preferences and/or food aversions of each individual, it is always “colored” with emotions (Den Uijl et al., 2014); consequently, food choices are often associated with emotional states (Van Trijip and van Kleef, 2008), expressed in dichotomies: pleasure/displeasure, ingestion/rejection, acceptance/rejection.

The act of eating is not simply related to the satisfaction of a biological need, as well it is primarily a social act, a relational act, starting from early childhood. As a result, the study of evolution of taste is intertwined with the study of mental and emotional development and reactivity; food is not only good to eat, but also to “think” (Fischler C., 1988).

According to anthropologists, food neophilia is the expression of a characteristic ancestral conflict of all omnivores (Fischler, 1988): on one hand the need to experiment and consume a wide range of food
products in order to meet biological needs and, on the other hand, the need to protect themselves from the risk of food poisoning inherent in each new experimentation.

Furthermore, in the development of individual food tastes at least four types of factors are involved: biological; psychological (relating to individual experience); cultural and social (i.e. the mechanisms of interaction between individuals). All of these aspects need to be investigated in depth by means of a sound research activity.

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